MAY 1960
No. 246

ASTM Bulletin

63rd Annual Meeting 5
Are Data Centers the Answer? 14
Self-Qualification of Laboratories 17
In Defense of Committees 24

American Society for Testing Materials

RESEARCH AND STANDARDS FOR MATERIALS

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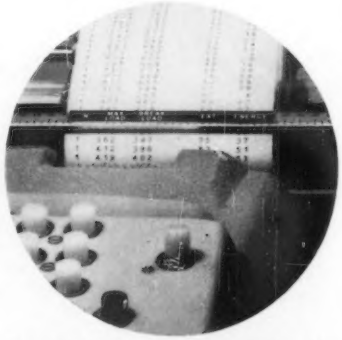

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May 1960 **Number 246**

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TECHNICAL PAPERS

Rheological Testing of Elastomers at Low Temperatures. Part II.—L. Boor, M. Hanok, F. Conant, and W. Scoville, Jr. *The extent to which certain superposition principles are applicable to analysis of different types of deformation of elastomeric material is examined* 25

A Technique for Gripping High-Strength Fabrics During Physical Tests—K. Plitt, and L. Dunlap. *The authors describe a method for laminating high-strength fabrics so that tensile and burst strengths may be more easily determined* 33

An Improved Method for the Determination of the Normal Consistency of Gypsum Plasters—R. A. Kuntze. *Modification of ASTM Test Method C-26 employing a conical instead of cylindrical plunger is proposed for determining the normal consistency of gypsum plasters* 35

A Vicat-Type Penetration Tester for Evaluating Hardness and Elastic Recovery in Polymeric Materials—K. Gardiner, T. Jordan, and F. Adams. *The authors have devised a Vicat-type instrument for evaluating hardness and elastic recovery in polymeric materials encountered in typical commercial applications* 38

A Reverse-Flow Viscometer—*Technical Note* by W. M. Robinson 40

Design Criteria for 6Al-4V Titanium Alloy at Room and Elevated Temperatures—M. Lemcoe and J. Childs. *To establish structural design criteria for 6 Al-4V titanium alloy, tensile, compressive, bearing, and shear properties were determined on bar and sheet material in the annealed condition from 75 to 1000 F* 41

Measurement of Surface Moisture and Sulfur Dioxide Activity at Corrosion Sites—P. J. Sereda. *This third and final progress report presents a method for correlating wetness-period sulfur dioxide activity with corrosion rate* 47

Measurement of the Brittleness Temperature of Polyethylene—A. Birks and A. Rudin. *A fast-acting temperature controller is one of the modifications proposed for ASTM Test Method D-746 that will speed up and reduce scatter from brittleness temperature tests* 49

An Improved Microhardness Tester for High-Temperature Use—J. H. Westbrook. *A motor drive raising the specimen against a deadweight loaded indenter mounted on a counterbalanced beam improves high-temperature microhardness testing* 53

ARTICLES

63rd Annual Meeting 5–7
Are Data Centers the Answer? 14
Plan for the Self-Qualification of Laboratories—A. T. McPherson 17
In Defense of Committees—R. Burns 24

DEPARTMENTS

ACR Notes	7	New ASTM Publications	8
Actions on Standards	10	New Members	74
Bookshelf	64	News of Members	80
Coming Technical Papers	93	Other Societies' Events	72
Deaths	84	OTS Reports	72
District Activities	19	Schedule of ASTM Meetings	13
Editorial	12	Technical Committee Notes	21
Index to Advertisers	95	Your Committee Officers	58
Laboratory Supplies & Equipment	86		

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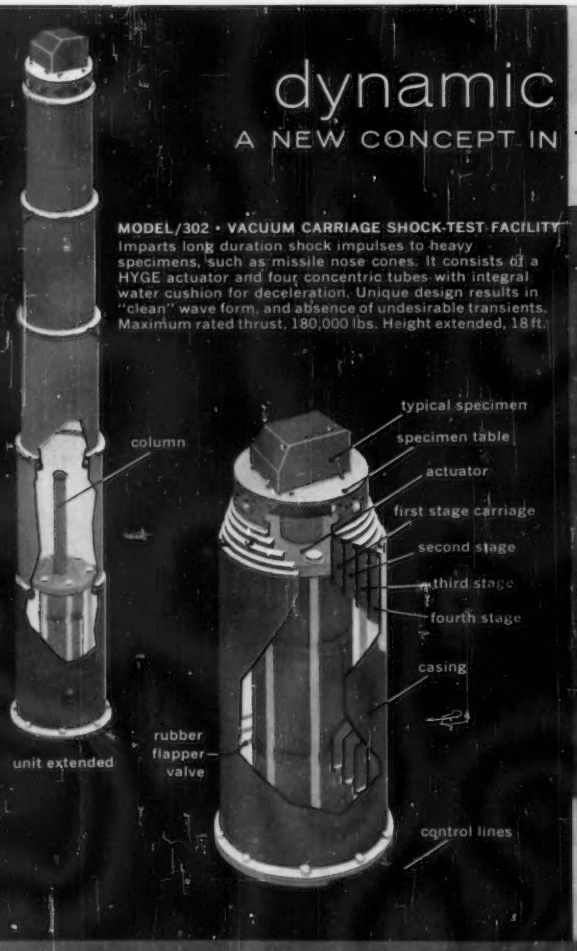

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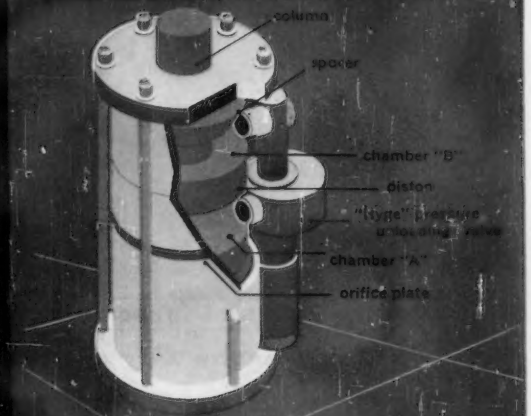

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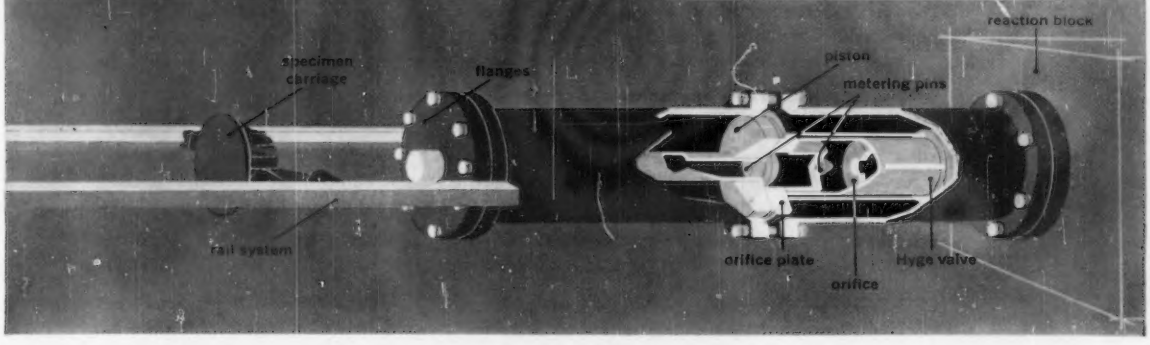

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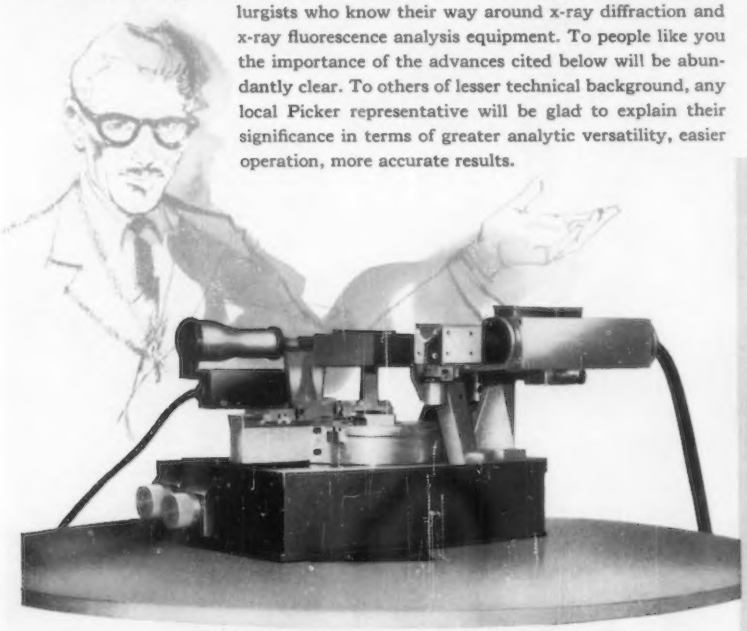

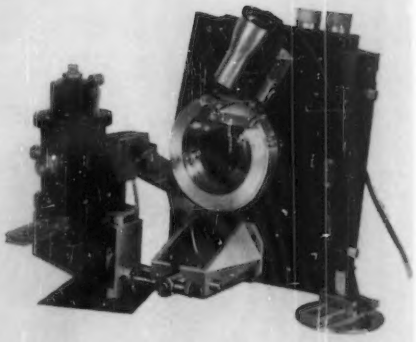

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ASTM BULLETIN

Research and Standards for Materials

Number 246 May 1960

63rd Annual Meeting

Recent Progress in Materials Sciences
Nature and Origin of Strength of Materials

Two symposia sponsored by the Materials Sciences Division will lead off the 63rd ASTM Annual Meeting, in Atlantic City, N. J., June 26-July 1, 1960.

NINE PAPERS ON THE fundamentals of materials will comprise the first two symposia to be sponsored by the Materials Sciences Division, to be presented on the opening day of the 63rd Annual Meeting, Monday, June 26, 1960. A Materials Sciences Luncheon will be held between the morning and afternoon sessions. The complete Materials Sciences program is as follows:

Symposium on Recent Progress in Materials Sciences

Recent advances in solid-state theory and application and the relation of structure to properties of materials will be treated in depth by the four speakers in this session. They will describe and interpret what is now known of why materials behave as they do. The papers and authors:

Accomplishments and Limitations of Solid-State Theory—*Harvey Brooks, Harvard Univ.*

The Influence of Surfaces on the Properties of Materials—*M. J. Sinnott, University of Michigan*

Mechanical Properties of Semiconductors—*J. N. Hobstetter, University of Pennsylvania*

Status of Ductile Ceramic Research—*E. R. Parker, University of California*

Materials Sciences Luncheon

The speaker at the luncheon will be William O. Baker, vice-president, research, Bell Telephone Laboratories, Inc. Dr. Baker is a member of the President's Board of Consultants on Foreign Intelligence Activities, chairman of the National Science Information Council, chairman of an advisory group in the Department of Defense, a member of the Committee on Industrial Chemistry of the National Research Council, and a past-member of the President's Science Advisory Committee. It is expected that Dr. Baker's talk will touch upon the establishment of interdisciplinary laboratories at certain universities and on research and education relating to the materials sciences.

Symposium on Nature and Origin of Strength of Materials

This session will focus on the single property, "strength," and will be conducted in an informal manner which it is hoped will elicit the maximum participation from the audience. The five speakers will approach the strength property from different viewpoints, collectively considering all major factors contributing to the strength of solid materials. The papers and authors:

Dislocation Motions and the Yield Strength of Solids—*J. J. Gilman, General Electric Co.*

Fatigue Strength of Crystalline Solids—*G. M. Sinclair, University of Illinois*

Resistance to Creep Deformation and Fracture in Metals and Alloys—*Frank Garofalo, U. S. Steel Corp.*

Brittle Fracture and the Strength of Metals—*E. T. Wessel, Westinghouse Electric Corp.*

Size and Shape Effects on Fracture of Solids—*George Irwin, Naval Research Laboratories*

Mass Spectrometry Committee Schedules Week-Long Meeting

At the June 27–July 1 meeting of Committee E-14 on Mass Spectrometry, to be held at the Hotel Dennis in Atlantic City, in conjunction with the Annual Meeting of the Society, some 85 papers are scheduled for presentation. Groups of papers of special interest will be presented in symposia on photo-ionization, precise measurement of uranium isotope abundance using UF_6, solids analysis, and ion rearrangement processes. Meetings will be held throughout the week. All interested persons are invited.

Provisional Program Changes

The provisional program summary appears on the following page. Full details were given in the April issue of the ASTM BULLETIN. Since the appearance of the April issue, a paper by N. G. Zoldners, Department of Mines and Technical Surveys of Canada, on "Effect of High Temperatures on Concretes Made with Different Aggregates" has been added to the Session on Cement and Plaster to be held Thursday, June 30.

The paper by W. J. Worley, University of Illinois, on "Mathematical Interpretation of Experimental Data" has been withdrawn. The paper was scheduled for presentation at the General Testing Session on Thursday morning, June 30. However, the paper will be published in the ASTM BULLETIN.

Several committee reports will be presented at sessions different from those shown in the April BULLETIN. These shifts have been made in the following program summary.

Summary of Provisional Program

The complete advance program and abstracts appeared in the April issue of the Bulletin. This program is subject to change.

Chalfonte-Haddon Hall

Atlantic City, N. J. — *June 27—July 1, 1960*

MONDAY, June 27	TUESDAY, June 28	WEDNESDAY, June 29	THURSDAY, June 30	FRIDAY, July 1
MORNING				
1 Opening Session—Symposium on Recent Progress in Materials Sciences	**7 Symposium on Acoustical Fatigue** **8 Symposium on Shear and Torsion Testing** **9 Symposium on Present Methods of Metallographic Specimen Preparation**	**18 Symposium on Radiation Effects and Radiation Dosimetry** **19 Session on Fatigue** *(Cont.)* **20 Session on Metals** —11:15 a.m.— **21 Report Session** (Reports D-7, D-8, D-10, D-12, D-13, D-14, D-15, D-21, D-22, E-4)	**27 Symposium on Low Temperature Properties of High Strength Aircraft and Missile Materials** **28 Session on General Testing** **Papers on Effect of Nuclear Bombardment of Rubber Materials** —11:15 a.m.— **29 Report Session** (Reports C-3, C-13, C-14, C-16, C-22, E-1, E-6 E-14)	**35 Symposium on Quality of Observations**
—12:00 noon— **Materials Sciences Luncheon**	—12:00 noon— **10 President's Luncheon**			
AFTERNOON				
2 Symposium on Nature and Origin of Strength of Materials	**11 Session on High Temperature** *(Cont.)* (Report Jt. Comm. Eff. Temp.) **12 Symposium on Shear and Torsion Testing** *(Cont.)* **13 Symposium on Present Methods of Metallographic Specimen Preparation** *(Cont.)*	—2:00 p.m.— **22 Symposium on Radiation Effects and Radiation Dosimetry** *(Cont.)* **23 Session on Metals** *(Cont.)* —3:00 p.m.— **Panel Discussion on Low Cycle Fatigue**	**30 Symposium on Low Temperature Properties of High Strength Aircraft and Missile Materials** *(Cont.)*	—12:30 p.m.— **36 Report Session** (Reports D-2, D-4, D-11, D-16, D-19, D-20, D-27, E-11, Jt. Comm. Leather) —12:30 p.m.— **37 Report Session** (Reports B-7, C-1, C-11, C-15, E-2, E-7, E-15)
—4:30 p.m.— **3 Report Session** (Reports B-3, C-12, C-18, C-20, D-3)	—4:30 p.m.— **14 Report Session** (Reports A-6 A-7, A-10, B-1, B-4, B-8, B-9, C-4, C-8, C-17, C-24, D-24)	—4:00 p.m.— **24 Report Session** (Reports A-1, B-2, B-5, B-6, E-3, E-13) **25 Report Session** (Reports C-7, C-9, C-21, D-1, D-9, D-17, D-18, E-5, F-1)	—4:30 p.m.— **31 Report Session** (Reports A-3, A-5, D-5, D-6, D-23, D-25, D-26, E-10, E-12)	
	—5:00 p.m.— **15 Gillett Lecture R. C. Dalzell Nuclear Fuel Element Development**	—4:30 p.m.— **26 Marburg Lecture Farrington Daniels Solar Energy**		
EVENING				
4 Symposium on Nuclear Methods for Measuring Soil Density and Moisture **5 Session on Concrete** **6 Session on High Temperature**	**16 Session on Soils for Engineering Purposes** **17 Session on Fatigue**	**Dinner Dance**	**32 Symposium on Low Temperature Properties of High Strength Aircraft and Missile Materials** *(Cont.)* **33 Session on Road and Paving Materials** **34 Session on Cement and Plaster**	
	Entertainment Feature "Slides on Africa"			

Electron Diffraction Techniques to Be Explored at Meeting

A program of activities in the field of electron diffraction will be organized at a meeting of Subcommittee XI on Electron Microstructure of Metals of Committee E-4 on Metallography to be held on Sunday, June 26, at 8:00 p.m., at Chalfonte-Haddon Hall. Considerable interest in standardizing electron diffraction procedures and techniques has been expressed at recent subcommittee meetings. This technique is closely associated with electron microscopy, since most electron microscopes are easily adaptable for electron diffraction.

Electron diffraction data have been presented at many of the annual symposia sponsored by Subcommittee XI. Papers on instrument modifications for routine electron diffractometry and on structural analysis, from the 1959 symposium, have been published in *STP 262* on Electron Metallography. One or more papers in this field will be included in the Annual Meeting symposium to be held on Tuesday, June 28.

If the activity resulting from the organizational meeting should result in the development of data useful in the identification of materials by electron diffraction, the publication of such data would be discussed with the Joint Committee on Chemical Analysis by Powder Diffraction Methods. This committee has been publishing X-ray diffraction data in card-file form for such purposes since 1939.

Anyone having an interest in electron diffraction is invited to attend the June 26 organizational meeting and to discuss this proposed new activity. It is hoped that a main result of the meeting will be to define those areas in the field of electron diffraction in which Subcommittee XI can make a useful contribution. Inquiries for additional information should be addressed to Mr. N. A. Nielsen, chairman of Subcommittee XI, E. I. du Pont de Nemours & Co., Inc., Experimental Station, Wilmington, Del.

ACR Notes

Administrative Committee on Research

Improving Secondary Education in Science

By E. I. SHOBERT II[1]

THE EDUCATION of our young people in science has been a subject of concern in this column in the past. In the October, 1959, ASTM BULLETIN, Mr. Walter Smith discussed a promising trend in student employment, and in the April, 1959, issue Dr. Archibald McPherson discussed science fairs. In the same general area, I should like to report a case history of what might be considered an unusual and profitable example of company, community, and school cooperation at the secondary level.

This report should be of interest to those living in suburban and small-town circumstances where facilities of the larger technical high schools are not available. St. Marys, Pa., scene of the case in point, is a town of about 8500 people.

This development probably started when the high school administration began to look at the curriculum in the light of the needs of industry in St. Marys. For those students not planning to go on to college the science and mathematics programs as well as the manual arts program were arranged to give the most useful training. The general course became one which gave more specific training in shop practice and shop mathematics. Four science courses were also made available.

The next step involved strengthening the mathematics curriculum for those in the college preparatory course. A course in college algebra was offered to those who were planning to go on to science or engineering. This course was taken during the junior year in high school at the same time as geometry.

After the college algebra course had been offered for two years, a group of students came along who were interested in carrying on with the sixth year of mathematics. The sixth course consisted of one semester of analytic geometry and one of introductory calculus. One group has been graduated and the second is now completing this series of courses in addition to the four science courses—general science, biology, chemistry, and physics.

The program has been supported by local industry in that the science and mathematics teachers have been taken into the laboratories during the summers and given technical work in line with their interests. The chemistry teacher has carried out a series of special projects in the chemical laboratory of our plant and the mathematics teacher has carried out special calculations for technical publications from our research laboratories.

Last summer the school and the industries in town arranged a two-week, half-day schedule of classes for outstanding high school juniors and seniors in which specialized subjects covering a broad range of science and mathematics were taught by scientists and engineers from local industries. About ten students completed this course, which was led off by a distinguished professor from The Pennsylvania State University.

Since this general program has been going on for several years, it is possible to see some of the results. Those students who have had the extra work in mathematics and science have been making well above average records at the colleges and universities where they are studying. They have gone directly into this work without additional preparation and are able to hold their own with the best.

In a high school of about 290 students in four grades, it took a rare combination of foresight and concern on the part of the administration, the school board, and the faculty to carry out this program. In addition to this regular school activity, some of the teachers involved have secured National Science Foundation scholarships to improve their abilities in these areas and to further their own education.

I am sure that some of the criticisms of our secondary educational system in general which have been made by men like Admiral Hyman Rickover are true. However, this program, which has been operating for several years, shows that circumstances can be improved even in a small community through the cooperation of an enlightened administration, an eager faculty, a far-sighted school board, and cooperating industries.

[1] Manager of Research, Stackpole Carbon Co., St. Marys, Pa.

NEW ASTM PUBLICATIONS

Atoms and Rockets Spur New Metal Uses

UNQUESTIONABLY, there is a great deal of effort now being expended on the newer metals. What has brought this about? Examination of the subjects covered in this *Symposium on Newer Metals* gives an answer: needs for materials with properties superior to those of existing materials for new applications in aircraft, nuclear energy, and communications.

These new applications did not come about as a result of the new materials that were available. Rather, the materials were developed in response to the new applications, because conventional materials could not serve adequately. This "materials lag" is the subject of a report published recently by the National Academy of Sciences–National Research Council (see p. 11).

Recent aircraft and missile applications are demanding more and more of materials. The advent of the turbojet engine was only a forerunner. Airframe materials for jet aircraft shifted from aluminum to titanium and steel when speeds approached Mach 3. Simultaneously with more severe requirements in jet engines, missiles and rocket motors were overstepping the bounds of conventional materials As the quest for greater power went on, it became evident that materials for rocket nozzles and control vanes was a critical problem.

An imminent development, manned space flight, has brought additional requirements for which the refractory metals are needed. If man is to reenter the atmosphere from space without burning up, some means of controlling the vehicle by an airfoil structure is needed. This embryonic wing would have a leading edge that could heat aerodynamically to temperatures of 2000 F or higher.

Nuclear reactor development is another major field which has spurred the development of the newer metals. Requirements here are for materials with a variety of properties, ranging from low thermal neutron absorption for the structural parts of the reactor to high cross-sections for control purposes.

Metallurgists, engineers, and designers should find this volume invaluable. Three distinct topics are covered: Properties of Refractory Metals; Nuclear and Light Metals; and Processing of Newer Metals.

The contents are:

Introduction—R. I. Jaffee

Universal High-Temperature Testing Machine for Vacuum or Controlled Atmosphere—M. J. Manjoine, L. L. France, and R. T. Begley

Mechanical Properties of Molybdenum and Molybdenum-Base Alloy Sheet—M. Semchyshen and Robert Q. Barr

High-Temperature Mechanical Properties of Tantalum—F C. Holden, F. R. Schwartzberg, and R. I. Jaffee

Effect of Oxygen and Nitrogen on Workability and Mechanical Properties of Columbium—R. T. Begley and L. L. France

Tensile Properties of the Platinum-Group Metals—F. C. Holden, R. W. Douglass, and R. I. Jaffee

Effect of Purity and Manufacturing Variables on Elevated-Temperature Properties of Beryllium—W. W. Beaver, R. G. O'Rourke, and J. N. Hurd

Stress-Rupture and Creep Properties of QMV Beryllium Metal—J. N. Hurd, R. G. O'Rourke, and W. W. Beaver

Test Methods Used for Zirconium and Zirconium Alloy in the Naval Reactor Program—Harold L. Kall

Effects of Heat Treatments on the Tensile a d Corrosion Properties of Zircaloy 2—J. G. Goodwin, L. S. Rubenstein, and F. L. Shubert

Survey of the Mechanical Properties of Yttrium and Yttrium Alloys—O. N. Carlson, D. W. Bare, E. D. Gibson, and F. A. Schmidt

Columbium and Tantalum Fabrication—H. M. McCullough

Deoxidation and Denitrification Studies of Chromium and the Effect on Low-Temperature Properties—H. L. Levingston and N. J. Grant

Review—The Fabrication of Tungsten—C. H. Toensing

Solubility of Nitrogen and Oxygen in Lithium and Methods of Lithium Purification—E. E. Hoffman

Coulometric Determination of Tin with Electrolytically Generated Iodine: Application to Analysis of Zircaloy—Roy D. Caton, Jr., and Harry Freund

STP 272, 266 pages, hard cover, price to be announced.

1959 Proceedings Now Available

THE ASTM *Proceedings*, Vol. 59, 1959, is now completed and has been mailed to members who have already requested it. This 1424-page volume records the technical accomplishments of the year, including reports and papers, together with discussions, offered to the Society during the year and accepted for the *Proceedings*. The volume includes the Summary of Proceedings of the ASTM 62nd Annual Meeting and the Summary of Proceedings of the Third Pacific Area National Meeting, listing by title and author the programs for each session.

There are 71 reports of technical committees which, together with appendices, provide a wealth of useful information, as do the 44 technical papers and discussions on a wide variety of subjects pertaining to research and standards for materials. For the benefit of members, the Annual Report of the Board of Directors highlights matters administrative, technical, and financial and includes a record of meetings held by Society Districts, information on membership gains, publications, honors and awards, and other matters of interest.

In addition to the papers and reports embodied in the *Proceedings*, there are listed all symposia and other special sessions published separately as Special Technical Publications and all papers published in the ASTM BULLETIN.

Although the Society's publications program has expanded greatly in recent years with an ever-increasing number of Special Technical Publications, the *Proceedings* remains the repository of factual information and a record of the Society's work. An important adjunct is a Subject and Author Index to all papers published in any form by the Society in 1959.

ASTM members are entitled to a copy of the *Proceedings* as a part of their membership. The price for nonmembers is $12.

Volume on Soils Issued

A VOLUME of 425 pages including two symposia and two other groups of papers dealing with various aspects of soils testing is now available. Included are: Symposium on Time Rates of Loading in Soil Testing; Symposium on Atterberg Limits; Papers on Soils presented at the ASTM Sixty-second Annual Meeting; and Papers on Soils presented at the ASTM Third Pacific Area National Meeting.

The Symposium on Time Rates of Loading deals with consolidation of clays and soils and evaluation of strain-rate effects in soils and contains an extensive literature survey on dynamic and static resistance of cohesive soils for the period 1846 to 1958.

Various aspects of the well-known Atterberg Limits tests are treated in that portion of the book. The additional papers cover such topics as soil-cement mixtures, soil stabilization, moisture-density tests, and triaxial compression tests. In all, the reader will find 31 papers in this extensive and comprehensive volume. The contents:

Symposium on Time Rates of Loading in Soil Testing

Introduction—Donald Burmister

Dynamic and Static Resistance of Cohesive Soil—1846 to 1958—W. S. Housel

The Influence of Rate of Strain on Effective Stresses in Sensitive Clay—C. B. Crawford

A Method for Adjusting Strain-Rates to Obtain Pore Pressure Measurements in Triaxial Shear Tests—W. Ellis and W. G. Holtz

Apparatus for Repeated-Load Tests on Soils—H. B. Seed and J. W. N. Fead

Strain-Rate Behavior of Clay and Organic Solids—D. M. Burmister

Automation in Consolidation Testing—R. H. Karol

Time Effects in the Consolidation of Clays—G. A. Leonards and B. K. Ramiah

The Use of Visco-Elastic Stress-Strain Laws in Soil Testing—R. L. Schiffman

Symposium on Atterberg Limits

Introduction—George F. Sowers

History and Development of the Atterberg Limits Tests—E. E. Bauer

Use of a One-Point Liquid Limit Procedure—W. J. Eden

Ohio Adopts the One-Point Mechanical Method for Determining the Liquid Limit of Soils—J. G. Joslin and H. D. Davis

Correlation of Atterberg Limits with Geology of Deep Cores from Subsidence Areas in California—D. A. Morris and A. I. Johnson

Investigations of the Liquid Limit Test on Soils—R. F. Dawson

Liquid Limit Results from Various Types of Grooving Tools—J. E. Mitchell

Recommendations for Changes in the Liquid Limit Tests—M. D. Morris, R. B. Ulp, and R. J. Spinna

Plastic Limit—Comparison of Cube and Standard Thread Test Methods—E. A. Abdun-Nur

Penetration Tests for Liquid Limit—G. F. Sowers, A. Vesic, and M. Grandolfi

Papers on Soils (Sixty-second Annual Meeting)

Laboratory and Field Tests of Granular Soil-Cement Mixtures for Base-Courses—M. S. Abrams

Powder versus Slurry Application of Lime for Soil Stabilization—D. T. Davidson, G. Noguera, and J. B. Sheeler

Improved Determination of Preconsolidation Pressure of a Sensitive Clay—J. J. Hamilton and C. B. Crawford

Papers on Soils (Third Pacific Area National Meeting)

Introduction—F. J. Converse

Measurement of Excess Hydrostatic Pressures in Soils—W. G. Weber, Jr.

Moisture and Strength Variation in a Thick, Uniform Clay Layer—W. G. Weber, Jr., and W. F. Kleiman

Extended Repetitive Plate Load Tests for the Evaluation and Design of Concrete Pavements—B. B. Gordon

Some Laboratory Studies of the Moisture-Density Relations of Soils—R. F. Dawson

The Effect of Temperature on Moisture Contents as Determined by Centrifuge and Tension Techniques—R. C. Prill and A. I. Johnson

The Effect of Particle Shape and Texture on the Strength of Noncohesive Aggregates—H. C. Morris

Triaxial Compression Tests on Soils Using Variable Lateral Pressure—R. H. Meese and R. W. Long

Soils Classification Triangle Based on the Unified Soil Classification System—Jack McMinn

STP 254, 425 pages, hard cover, price to be announced.

Spectroscopy

THE USE of various sections of the electromagnetic spectrum for analytical and research purposes has expanded in recent years at a tremendous rate. This symposium concerned with "unsolved problems" includes representative papers in six distinct fields of spectroscopy. The reader will find advanced thinking in emission, X-ray, flame photometry, ultraviolet absorption, magnetic resonance, and infrared spectroscopy. In addition to treatment of many sophisticated approaches to analytical problems, the book contains a report on Soviet progress in the field of molecular spectroscopy.

Several papers in this very comprehensive volume contain bibliographies which in themselves can be considered valuable additions to the literature, particularly in the area of flame photometry.

The contents include:

Introduction—J. B. Marling

Challenges in Atomic Spectroscopy—J. R. McNally, Jr.

Spectroscopy of Radioactive Materials—J. G. Conway

Communications in Spectrochemical Analysis—D. L. Fry

Application of X-Ray Spectroscopy to Unsolved Problems in Geochemistry—I. Adler

The Future of X-Ray Fluorescence Instrumentation—J. W. Kemp

Spectroscopy in the Region 175 to 200 mμ—W. W. Kaye

Analytical Flame Photometry: New Developments—P. T. Gilbert, Jr.

Special Problems in the Determination of Tetraethyllead in Gasoline by Flame Photometry—B. E. Buell

The Unpaired Electron via Electron Paramagnetic Resonance Spectrometry—R. H. Sands

Maser Applications and Traveling-Wave Techniques for Magnetic Resonance Spectroscopy—A. E. Siegman

Band Nomenclature for the Ultraviolet Spectra of Conjugated Organic Compounds—F. W. Forbes and R. Shilton

Some Comments Concerning Quantitative Infrared Spectroscopy—W. C. Steele and W. K. Wilson

A Technique for Preparing Solid Organic Samples for Infrared Analysis—L. A. Strait and M. K. Hrenoff

The Combination of Methods in the Analysis of Complex Hydrocarbon Systems—N. D. Coggeshall and W. Hubis

Molecular Spectroscopy in the USSR—D. G. Rea

Ultraviolet Spectroscopy: Aromaticity of Carbonaceous Materials: Absorption Errors—R. A. Friedel and J. A. Queiser

STP 269, 262 pages, hard cover, price $7.00, to members $5.60.

Effect of Water-Reducing and Set-Retarding Admixtures on Properties of Concrete

THE USE of water-reducing admixtures and set retarders in concrete has grown continuously since their introduction over 25 years ago; it is estimated that they are now used in the production of 25 million cubic yards of concrete annually in the United States alone. Further indication of current interest is the fact that ASTM Committee C-9 on Concrete and Concrete Aggregates and certain public agencies are evolving standard methods of test and specifications to govern the purchase and performance requirements of these admixtures for concrete.

The future of better concrete lies in an increased understanding of concreting materials and the best manner of combining them to produce the maximum in strength and durability.

This symposium consists of ten papers and a summary. Four of the papers represent the joint contribution of four principal producers of admixtures. The remaining papers were prepared by representatives of consumer interests, research organizations, and the cement industry.

The papers are:

Introduction—Bruce Foster

Actions of Calcium Sulfate and Admixtures in Portland Cement—W. C. Hansen

Structural and Lean Mass Concrete as Affected by Water-Reducing, Set-Retarding Agents—George B. Wallace and Elwood L. Ore

Observations in Testing and Use of Water-Reducing Retarders—Lewis H. Tuthill, Robert F. Adams, and John M. Hemmeke, Jr.

Effect of Water-Reducing Admixtures and Set-Retarding Admixtures as Influenced by Portland Cement Composition—Miles Polivka and Alexander Klein

Field Experience Using Water-Reducers in Ready-Mixed Concrete—E. L. Howard, K. K. Griffiths, and W. E. Moulton

Detection of Lignosulfonate Retarder in Cement Suspensions and Pastes—E. G. Swenson and T. Thorvaldson

Introductory Producers' Paper on Water-Reducing Admixtures and Set-Retarding Admixtures for Concrete—M. E. Prior and A. B. Adams

Effect of Water-Reducing Admixtures and Set-Retarding Admixtures on the Properties of Plastic Concrete—Charles A. Vollick

The Effect of Water-Reducing Admixtures and Set-Retarding Admixtures on the Properties of Hardened Concrete—D. R. MacPherson and H. C. Fisher

Water-Reducing Admixtures and Set-Retarding Admixtures for Concrete: Uses, Specifications, Research Objectives—Richard C. Mielenz

STP 266, 256 pages, hard cover, price $7.50, to members $6.00.

Durability of Sandwich Construction

THE AIRCRAFT and building construction industries are making widespread use of the structural sandwich panel, made possible through simultaneous developments in the structural adhesive and the lightweight core material fields. Considerable savings in weight, assembly time, and costs have been realized, with the added advantages of improved appearance and smoothness.

This Symposium on Durability and Weathering of Structural Sandwich Construction, while not a complete study of durability and service experience, adds to the rather meager published information. It is hoped that this publication will answer some questions concerning service performance in this relatively new area. The contents:

Effect of Normal Aging on Strength of Glass-Fiber Reinforced Plastic Honeycomb Cores—A. C. Marshall
Effect of Natural Environment on Sandwich Structure with AMS 3722 Paper Honeycomb Core—R. F. Zemer
Effect of Environmental Exposure on Adhesive-Bonded Structures—A. J. Tuckerman
Service Experience with Sandwich Construction—Some Approaches to Problems in Aircraft Application—J. P. Reese
Temperature Rise in Structures Due to Solar Heating—D. K. Rider
Effect of Climatic Variation on Polystyrene Foam Core Sandwich Panels in Roofs and Walls—E. A. Edberg
Experiences with Structural Sandwich in Building Construction—R. A. Biggs

STP 270, 100 pages, hard cover, price $3.00, to members $2.40.

Supplement to 1958 Compilation of ASTM Standards in Building Codes

THIS 1960 Supplement to the 1958 Compilation of "ASTM Standards in Building Codes" calls attention to the revised standards and the new and revised tentatives in the construction field that have been accepted by the ASTM since the appearance of the 1958 edition.

Among the topics covered are admixtures; mineral aggregates; asbestos-cement products; bituminous roofing and waterproofing; brick; cement; structural clay tile; concrete; concrete pipe; concrete masonry units; copper pipe, tube, and sheets; gypsum; iron; lime; masonry mortar; building stone; drain tile; plastics; refractories; and wood and steel products. Fire tests, flash point tests, and general testing methods are included.

268 pages, heavy paper cover, price $3.25, to members $2.60.

Actions on Standards

THE ADMINISTRATIVE COMMITTEE ON STANDARDS is empowered to pass on proposed new tentatives and revisions of existing tentatives, and tentative revisions of standards offered between Annual Meetings of the Society. On the dates indicated the Standards Committee took the following actions. Anyone interested in securing copies of the standards should write to Headquarters regarding their availability.

Shipping Containers

(Accepted March 23, 1960).

Standard Method of Test for Shipping Containers in Revolving Hexagonal Drum (D 782–47)

Revision and Reversion to Tentative.—Refinements have been made in mechanics of test and in the interpretation and application of test results.

Petroleum Products

(Accepted March 23, 1960).

Emergency Method of Test for Ultraviolet Absorptivity of Waxes (ES 50)

New Method.—The Pure Food and Drug Administration now requires petroleum waxes to meet certain criteria regarding oil content, color, congealing point, and ultraviolet absorption if the waxes are to be certified as safe for food applications. ASTM standards have been available for three of the criteria, but none existed for ultraviolet absorption of waxes. The method has been issued as an Emergency Standard in view of the urgent need for it, and Committee D-2 plans to recommend it for publication as tentative as soon as possible.

Plastics

(Accepted March 23, 1960).

Tentative Specification for Polytetrafluoroethylene Rod (D 1710–60 T)

New Tentative.—This specification covers rod of $\frac{3}{16}$-in. through $1\frac{1}{2}$-in. nominal diameter made wholly from polytetrafluoroethylene resin. The increasing commercial importance of these rods led to a demand for specifications covering them.

Tentative Method of Test for the Determination of Gas Evolved from Chemical Blowing Agents (D 1715–60 T)

New Tentative.—This method describes a procedure for determining the volume of noncondensable gas evolved by chemical blowing agents heated beyond their decomposition point. The volume of gas evolved is determined by difference in a mercury-filled gas buret. The industry representatives in ASTM and in the Society of the Plastics Industry had requested this method as a primary means of controlling the quality of the product being offered to the consumer.

Tentative Method of Test for Resistance of Plastics to Sulfide Staining (D 1712–60T)

New Tentative.—Plastic compositions containing salts of lead, cadmium, copper, antimony, and certain other metals (as stabilizers, pigments, driers, or fillers) may stain due to the formation of a metallic sulfide when in contact with external materials that contain sulfide. Materials that may cause sulfide stains are rubber, industrial fumes, foods, kraft paper, etc. This method provides a means of estimating the relative susceptibility of plastic compositions to sulfide staining.

Cast Iron

(Accepted April 14, 1960)

Standard Specifications for Gray Iron Castings (A 48–56)

Revised and Reverted to Tentative.

Tentative Method for Transverse Testing of Gray Cast Iron (A 438–60 T)

New Tentative.—For many years Specifications A 48 have included both the tension test and the transverse test for qualifying castings in accordance with the specifications. The revision of Specifications A 48 eliminates the description of the transverse test which is now covered in the new Tentative Method for Transverse Testing of Gray Cast Iron (A 438–60 T). Provision still remains in Specifications A 48 that the transverse test can be used as an optional method of qualification by agreement between the manufacturer and purchaser. When a transverse test is specifically authorized as a basis for acceptance, minimum test values shall be established by agreement between the manufacturer and purchaser, and the test will be conducted according to the new Method A 438.

Zirconium for Nuclear Applications

(Accepted April 14, 1960)

Tentative Specification for Zirconium Sponge and Other Forms of Virgin Metal for Nuclear Applications (B 349–60 T)

Tentative Specification for Zirconium and Zirconium Alloy Ingots for Nuclear Applications (B 350–60 T)

Tentative Specification for Hot-Rolled and Cold-Finished Zirconium and Zirconium Alloy Bars, Rod, and Wire for Nuclear Applications (B 351–60 T)

Tentative Specification for Zirconium and Zirconium Alloy Sheet, Strip, and Plate for Nuclear Applications (B 352–60 T)

Tentative Specification for Wrought Zirconium and Zirconium Alloy Seamless and Welded Tubes for Nuclear Service (B 353–60 T)

New Tentatives.—Specification B 349 covers virgin zirconium metal which is commonly designated as sponge because of its porous, spongelike texture, but may also take other forms. One grade, designated as Reactor Grade R-1, suitable for use in nuclear applications, is described. The most important characteristic of the reactor grade is its low nuclear cross-section as achieved by removal of hafnium and careful quality control in manufacturing procedures to prevent contamination with other high-cross-section materials.

Specification B 350 covers the vacuum-arc-melted product. The zirconium ingot is identified as Type R-1, and zirconium alloy ingot as Type RA-1. Type R-1 zirconium, and Type RA-1 zirconium alloy are also covered in Specifications B 351, B 352, and B 353.

Specification B 351 covers hot- and cold-finished zirconium and zirconium alloy bars, rod, or wire, other than required for reforging, including rounds, squares, and shapes in the grades used for nuclear requirements.

Specification B 352 covers hot- and cold-rolled zirconium and zirconium alloy sheet, strip, and plate in the grades used for nuclear requirements. The products covered include sheet 24 in. or more in width and under 0.187 in. in thickness; strip less than 24 in. in width and under 0.187 in. in thickness; and plate over 10 in. in width and 0.187 in. and over in thickness.

In the tubing specification (B 353), since nuclear grade tube is used for a wide variety of applications, basic nondestructive tests are outlined in Section 11. Other nondestructive tests are left to agreement between the purchaser and the manufacturer at the time the order is placed.

Thermal Insulating Materials

(Accepted March 23, 1960)

Tentative Recommended Practice for Prefabrication or Field Fabrication of Thermal Insulation Fitting Covers (C 450–60 T)

New Tentative. — This recommended practice consists of a manual of dimensional standards for the fabrication of thermal insulation fitting covers to be published separately, and a preface to appear in the Book of Standards. The recommended practice is considered to be an extremely useful as well as necessary aid in the proper use of thermal insulating materials as covered by other ASTM standards.

Tentative Specifications for Calcium Silicate Block-Type Thermal Insulation (C 344–54 T)

Tentative Specifications for Calcium Silicate Thermal Insulation for Pipes (C 345–54 T)

Revision.—Corrections and changes in text and values based on more modern products have been made as a result of considerable use of the methods.

Tentative Specifications for Mineral Wool Block or Board Thermal Insulation for Low Temperatures (C 378–56 T)

Revision.—The text and factors have been changed to meet present-day standards.

Electrical Insulating Materials

(Accepted March 23, 1960).

Tentative Definitions of Electrical Terms (D 1711–60 T)

New Tentative.—These definitions provide terminology and definitions of basic terms relating to electrical insulating materials. The definitions have been coordinated with those proposed by Sectional Committee C-42 on Definitions of Electrical Terms.

Academy–Research Council Group Says "Materials Barrier" Holds up U. S. National Security Programs

". . important national security programs, particularly those in defense, atomic energy, and space, are currently up against a materials barrier because the properties of most presently available materials are inadequate for the high-performance end-items that must withstand severe temperature, pressure, radiation, corrosion, and stress environments."

This is a conclusion of a National Academy of Sciences–National Research Council Special Committee on Scope and Conduct of Materials Research.

In its report, published by NAS–NRC in March, the committee declared that the lag in the development of new metals, ceramics, and plastics is—at this moment—holding up the development of nuclear-propulsion systems and space vehicles, as well as better missiles, rocket motors, naval vessels, and electronic devices for which theoretical designs now exist.

The committee was established last spring by Academy–Research Council President Detlev W. Bronk to survey "the total materials research and development activities of the nation—industrial, academic, and governmental—for the purpose of identifying any critical gaps." Dr. Clyde Williams, formerly president and director of Battelle Memorial Institute, was named chairman.

In transmitting the committee's report to Dr. Bronk, Dr. Williams wrote, "Considering all aspects of resources being utilized to resolve present materials problems, the committee considers that substantial inadequacies exist with respect to research programs, resources of personnel and facilities, and administrative procedures and organizations."

In its report, "More Effective Organization and Administration of Materials Research and Development for National Security," the committee recommends that ". . . the Government accord high priority in national security plans and programs to the science of materials and to the development of new and improved materials for national security uses, and that the relevant programs of the agencies and departments be strengthened.

"There are no magic administrative or technical solutions to the materials problem," the committee noted. "What is needed is significant strengthening at every level of activity." The report then listed five general recommendations:

1. Greater centralization of responsibility, more support for, and more effective coordination of Government-sponsored materials research and development programs.

2. Government incentives to encourage research and development on new and improved materials.

3. Assurance of adequate U. S. supplies of every chemical element or material to support full production and use of new and improved materials.

4. Improvement and acceleration of the dissemination of research information.

5. Strengthening of the universities in their dual role of training scientists and engineers and also of doing basic research.

Recognizing that "some efforts along the above lines are already under way in many quarters," the committee expressed the belief that "much more must be done."

The tiny diode, used in complex computers and industrial control equipment, is no larger than the flint in a cigarette lighter. Large-scale electronic computers employ several diodes in each "decision" circuit to permit rapid switching of input pulses.

ASTM Bulletin

No. 246 May 1960

Nineteen-Sixteen
Race Street
Philadelphia 3, Pa.

A New Name for ASTM?

AN EDITORIAL by ASTM President F. L. LaQue in the February ASTM BULLETIN solicited opinions from our members on the question of changing the name of the Society. A number of replies have been received, both pro and con. Excerpts from some of the letters appear below:

". . . there is much validity to the position that the title does not adequately cover the Society, both from the standpoint of prestige and meaning. My suggestion . . . Society for Materials Testing and Research."

"I suggest as the best name Association for Technology of Materials. It appears to me that the best name among those mentioned in the editorial is Association for Standards and Technology of Materials, but that is entirely too long. The technology of materials includes the development of standards."

"Everyone seems to agree that we keep the ASTM initials, but I wonder how many would agree that we use them . . . in reverse order—Materials Technology and Standards Association."

". . . the name as it now stands does not indicate that the first half of the purpose of the Society is 'the promotion of knowledge of the materials of engineering'. . . I suggest that you conduct a poll. . ."

"Association for the Sciences of Testing and of Materials. This name places emphasis on research, that is, on the scientific work which must underlie all ASTM standards."

". . . there would not seem any real reason for altering the acknowledged title of the Society and all it implies. . . If some change in the present title is, in the opinion of the majority, desirable, the most suitable, as a play on the present initials, seem to be covered by the suggestions in the president's letter."

"You are quite right in inferring that the word 'testing' as generally understood by industrialists carries a slightly derogatory aura . . . For Society prestige 'testing' should be dropped . . . the following are suggested: American Society for Technical Materials, American Society for Technology of Materials, Association for Science and Technology of Materials."

"Of the suggested names I have seen, I like best Association for Standards and Technology of Materials."

". . . what about Association for the Science and Testing of Materials."

"Association for Scientific Testing of Materials."

"Could not the BULLETIN print a ballot . . . I like the idea of retaining the initials ASTM but would not object to either of the names suggested by President LaQue. How about . . . Association for Standardization in the Technology of Materials."

"American Society for Technical Materials."

"I have been under the impression for a long period of time that the present name of the ASTM is misleading. . . I . . . suggest Academy of Standards and Testing Methods; Authority on Specifications and Testing Methods."

"I submit the following: Society for Materials Specifications and Testing Methods. . . Yes, 'American' has been dropped, not for lack of patriotism, but it's about time our engineers and scientists got their international feet wet."

"May I respectfully suggest American Society for Technological Methods."

"It appears to me that the best change of name would be to American Society for Technology of Materials."

"Since everybody seems agreed that any new name for the Society should fit the initials ASTM, why not just make this the official name of the Society. . ."

"Association for Applied Standards to the Technology of Materials."

"I believe that [the] name . . . Association for Standardization and Technology of Materials, is suitable."

"American Standards for Testing and Materials."

". . . I can find little evidence to justify a change in the name of the Society, the letters ASTM, or the statement of scope generally associated with its name . . ."

"There is too much involved and identified with the name ASTM to change it . . . I am for leaving the name of ASTM alone, and changing whatever is necessary in the scope of its activities."

"It would be a *calamity* to change the name, and of course I do not wish such on ASTM. The world knows what ASTM stands for, the growth of the Society has been with that name, we are proud of that name, and the founders would not want the name changed. To change the name would gain us nothing and on the other hand make unnecessary confusion."

What Makes ASTM?

Editor's Note.—This editorial was prepared by and represents the viewpoint of the chairman of one of our active technical committees. We subscribe wholeheartedly to the sentiments expressed.

THE OFT-REPEATED phrase that "clothes make the man" holds about as much truth as does a huge membership roster in indicating the inherent value of a technical society. Accomplishment, not size, is the criterion, and, in this respect, ASTM is most outstanding. But why?

The real answer lies in the fact that the keystone of the Society structure is the successful committee, success being measured in terms of meeting the ever-increasing demands of our materials technology for new materials and new test methods for all of which standards of quality must be established. As a consequence, the producer, the consumer, the scientist, and the engineer all have important roles in the effectiveness of the committee operation. Obviously, the success of the committee is predicated entirely on how well these several roles are played. Succinctly, it is the quality of the teamwork exhibited by each and every member of the committee that is directly responsible for committee achievement. To state this

in other words: if each member of the committee "team" is ready and willing to do his share of the chosen tasks, if he is willing to *give* of his knowledge, experience, and time, as his contribution to the common good—by which all can then benefit—then the efforts of the group will meet with success.

On the other hand, there sometimes is heard the complaint that a committee is "inactive," or that it never seems to accomplish its selected tasks. Such might infrequently be true; but if so, the underlying cause is usually found to be lack of teamwork—particularly in that area where the individuals involved are more selfishly concerned with "getting" rather than "giving." That this is an intolerable situation should be abundantly clear; for if one party is to "get," then another must have something to "give"; and this "giving" is not purely altruistic, because those who do so are usually quite aware of the fact that this is part of the teamwork that leads to attaining the ultimate goal to which the committee aspires. Thus, seen in this light, criticism of a committee's inactivity might be unwitting evidence of too little willingness to "give," and subsequently boomerang into an unintended self-indictment.

Faced with the quite obvious present situation wherein our rate of engineering accomplishments have far outsped our materials technology, it becomes increasingly more imperative that the committees of our Society should operate most effectively in their efforts to overcome this lead. To meet these demands of the future, our committees need more than names on a roster; they need a roster of working personnel who have well earned the right to be listed as members.

This is what makes ASTM!

Schedule of ASTM Meetings

This gives the lastest information available at ASTM Headquarters. Direct mail notices of all district and committee meetings customarily distributed by the officers of the respective groups should be the final source of information on dates and location of meetings. This schedule does not attempt to list all meetings of smaller sections and subgroups.

June 16–17	Committee F-1 on Materials for Electron Tubes and Semiconductor Devices	Boston, Mass. (Hotel Statler)
June 26–July 1	**Annual Meeting**	**Atlantic City, N. J. (Chalfonte-Haddon Hall)**
Sept. 13–15	Committee B-5 on Copper and Copper Alloys, Cast and Wrought	Niagara Falls, Ont. (Sheraton-Brock Hotel)
Sept. 27–29	Joint ASTM-TAPPI Committee on Petroleum Wax	Grand Rapids, Mich.
Oct. 17–18	Committee B-9 on Metal Powders and Metal Powder Products	Philadelphia, Pa. (ASTM Headquarters)
Oct. 18–21	Committee D-13 on Textile Materials	New York, N. Y. (Sheraton-McAlpin Hotel)

ASTM Role in Occupational Safety Summed up by N. L. Mochel

THE 2645 ASTM standards already on the books abound in contributions to the safety of mankind. At the Workshop on Setting Safety Standards for Tomorrow's Materials, part of the President's Conference on Occupational Safety, in Washington, D. C., March 1–3, 1960, ASTM Past-President Norman L. Mochel gave a capsule summation of the work already accomplished by the Society in the field and stated that ASTM is prepared to play its full part in ensuring the safety of mankind in the years to come.

Citing the ASME Boiler and Pressure Vessel Code as an example, Mr. Mochel observed that "This Code looks to the ASTM for most of the materials and the testing practices called for in the Code. Approximately 100 ASTM specifications for ferrous materials, and 50 specifications for non-ferrous materials, are used as the basis for design stresses in the Code." ASTM standards are also looked to for ensuring the integrity of piping, castings, forgings, and welded structures, and also the materials used in bridge and building construction.

"The air we breathe is rather important to all of us," said Mr. Mochel. "Air pollution has long been recognized as a problem. Many cities are doing something about coal smoke. But with our ever-increasing industrialization, new pollutants, such as oxides of sulfur and nitrogen, ozone, hydrocarbons, and particulate matter in a variety of forms have appeared. Nuclear reactions in recent years have increased the problem. Many national organizations and governmental bodies are engaged in the matter. ASTM's Committee D-22 on Atmospheric Sampling and Analysis is working almost wholely in an area that has application to the safety and well-being of the general public in matters relating to air pollution."

Also cited by Mr. Mochel was the work of Committee D-26 on Halogenated Organic Solvents, through its Subcommittee on Industrial Hygiene, in establishing criteria for the safe use of these solvents, many of which are considered to be quite toxic. The potential destructiveness of fire is also recognized in many ASTM test methods, such as those for flash point of volatile flammable materials, flammability of clothing textiles, fire retardency of paints, fire tests of building construction and materials, fire hazard classification of building materials, fire tests of roof coverings, flammability of treated paper and paperboard, and flash point of solvent-type liquid waxes.

"Probably nothing is more important in man's present development than readily available, relatively cheap electric power," Mr. Mochel stated. "And with this comes the need for protective materials, protective practices, safeguarding all against electric shock and fire hazards. Specifications for rubber insulating gloves, for rubber matting for use around electric apparatus, for rubber insulating blankets, for rubber insulator hoods, for rubber insulating line hose, for rubber insulating sleeves, for low-voltage rubber insulating gloves are but some that may be referred to in this field."

Other areas in which safety is a primary consideration in ASTM work include recommendations for the safe use of oxygen combustion bombs, practices for installation and safe operation of the spectrochemical laboratory, safety in the chemical analysis of metals, thermal shock tests for glass containers, and the relatively new efforts in the field of surface slipperiness and skid resistance.

Looking to the future, Mr. Mochel noted that "Materials development and the fixing of safety standards have no hard and fast lines drawn between today and tomorrow. The past, the present, tomorrow are a matter of constant change, development always, each development leading on to the next." He emphasized that the foregoing were "just a few examples out of the many services being rendered by the ASTM, through the voluntary efforts of its widespread and select membership. It is a rapidly growing organization. It has served well, it is very active in so many fields at present, it may be counted on for even greater services in the more complex days of tomorrow."

Are Data Centers the Answer?

Does the materials information you need exist in some report, data sheet, or handbook? Or must you get it from an expensive, time-consuming research program?

Say you are a materials engineer with a project team having the assignment to design elements of a guidance computer for a missile, or a pressure vessel for a new chemical process, or an advanced sonar. The designers on the team look to you for advice on materials. More often than not they are looking for a material with some "impossible" combination of properties—not just one property. You are an old hand in the materials field. Just from your experience, you can immediately put them in the right ballpark as to the general composition of material that might do the job. But to select the right material, if it exists, or to say with assurance that it doesn't and therefore either the design must be changed to use the best material available or the right material must be developed, you must call on sources other than your memory. Your office bookcase is lined with handbooks and other references giving many of the common properties of standardized materials, and your company library or technical information center has more.

Much of this information comes to you from the materials suppliers. You find that a good portion of manufacturers' data on materials is comparable, because they used ASTM or other standard tests and conditions in determining properties. But comparing data on combinations of properties of many competitive materials may take more time than you have and may still leave you up in the air because of uncertainties in the way the data were obtained.

After you have exhausted these sources—then what? Is there some way to turn over the search to a specialized materials information center especially staffed and equipped to find the information for you and to verify its reliability?

> "The entire field of research and development is affected by serious problems of dissemination of the results of the vastly expanded Government and industrial programs. Materials represent an aggravated case of the general problems because of the requirement for early application in complex devices of all new developments."
>
> *Report* of the Clyde Williams Committee[1]

The answer is a qualified yes; there are a few such centers. Some are set up according to classes of materials, as the Defense Metals Information Center at Battelle Memorial Institute and the Plastics Technical Evaluation Center at Picatinny Arsenal, both of which are sponsored by the Department of Defense. Others are organized according to properties or environment, such as the Thermophysical Properties Research Center at Purdue University or the Radiation Effects Information Center at Battelle.

The popularity of such information centers is growing, no doubt based on clear evidence of their usefulness. Indeed, a recent survey[2] conducted by the Materials Advisory Board of the National Research Council for the Department of Defense shows in no uncertain terms that such centers are wanted and needed. The Department of Defense points out, however, that those surveyed were not necessarily a true cross-section of users of technical information centers, and the results should be taken as only generally indicative.

The MAB Survey—What It Shows

Of the over 2000 (57 per cent) returns to a comprehensive questionnaire, 87 per cent favored the general idea of materials information centers. Only 4 per cent did not. Most would still favor the idea if a charge were imposed, though depending on the amount. More than half would like to see such centers limited solely to materials, though a substantial number felt that the same centers could also cover general scientific subjects.

The question of how to divide the task for disseminating materials information is of special interest to ASTM members; most preferred a division that roughly parallels the ASTM committee structure. Of the four alternate ways to classify materials information, the respondents showed preferences as follows:

By type of materials (metals, plastics, etc.)	1016
By individual material (vanadium, zirconium, polyethylene, etc.)	654
By properties of materials (thermoelectric, refractory, etc.)	445
By end-use of materials (rocketry, electronics, etc.)	241
Other	132

It was evident, too, that users of materials information wanted to draw on all available sources world-wide, including foreign-language literature. Russian, German, and French were listed with high priority as languages to be abstracted, with some complete translations.

Particular categories of materials in which more effort to disseminate information is needed were listed in part as follows:

Refractory metals	Steel and iron
Lightweight metals	High-strength materials
Plastics	
Ceramics	Finishing, coatings, deterioration prevention, corrosion
Refractory materials	
Nuclear materials	
Electro-materials	

Also listed, but with lower priority, were high-energy fuels, thermal insulation, organics and petroleum products, ultrapure materials, magnetic materials, and bearing materials.

Aside from abstracts of technical papers on materials, with which most of the survey was concerned, the respondents were much concerned with availability and sources of materials as well as compilations of properties data. Materials processing techniques and uses were also mentioned by a number of respondents as being of special interest.

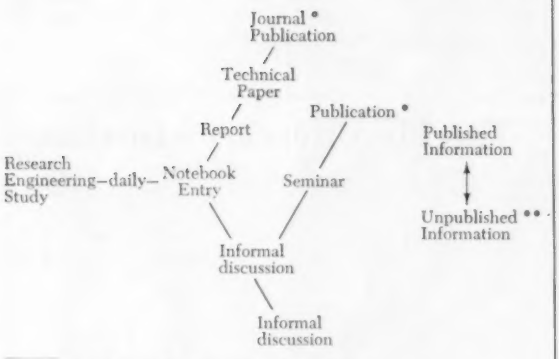
[1] More Effective Organization and Administration of Materials Research and Development for National Security, National Academy of Sciences–National Research Council, Publication 718 (1960).

[2] Staff Study on Dissemination of Technical Information About Materials and Materials Research, Part I. Interim Report; Materials Advisory Board, National Academy of Sciences–National Research Council (MAB-51-SM), Sept., 1959.

TABLE I.—FLOW OF INFORMATION FROM POINT OF ORIGIN TO POINT OF USE.

Courtesy NAS-NRC[1]

ORIGIN OF INFORMATION



* Information actually published may represent only a small fraction of that in the original reports with the result that much information is lost; moreover, there is a great time-lag between original work and its publication.

** A high percentage of engineering studies are not published, with some real advantages in not cluttering the general literature but much loss in information useful to a few individuals who may have to repeat in the same work.

FUNCTIONS OF LIBRARIES OR INFORMATION CENTERS

Collection	*Dissemination*
A. Libraries or Agencies Concerned with Published Information	
1. Collect journals and books	1. Disseminate what has been written a. Bibliographies b. Abstracts c. Reports
2. In some cases collect reports	
B. Information Centers Concerned with Published and Unpublished Information	
1. Actively seek for information from current investigator	1. Disseminate summarized and evaluated information
2. Actively seek for current reports	2. Disseminate what is currently being done
3. Collect journals and books	3. Disseminate who is currently doing what

USERS OF INFORMATION

1. Research Investigators need
   a. Reference to and access to complete reports
   b. Reference to and discussions with current investigators
2. Engineers need
   a. State-of-art reports
   b. Handbook and evaluated data
   c. Reference to and discussions with current investigators
3. Administrators need
   a. State-of-art reports
   b. Summaries of current programs
   c. Reference to and discussions with current investigators

Scientific Soundness

A designer would certainly not base his design on a reported property of a material without some kind of verification. Whether this verification or checking should be done by an information center or by others was a question on which the respondents were about evenly divided. About the same number replied "yes," "no," and "sometimes," when asked whether the information center should do this.

Extensive comments from those who answered "yes" indicated several patterns of replies. Most felt that technical experts should evaluate the information. They might be employed by the center full time, or they might be consultants, or serve on advisory committees. But it was evident from the variety of replies that evaluation of information is no easy task, nor is there any clear-cut procedure for doing it.

Sources of Information on Materials

The questionnaire asked which types of institutions were likely sources of information. The bulk of the respondents checked academic institutions, nonprofit institutions, and government bodies in about equal numbers for the three.

A question about present use of a number of existing information sources, such as the Armed Services Technical Information Agency, Office of Technical Services, John Crerar Library, Defense Metals Information Center, and *Chemical Abstracts*, showed a surprisingly large number (about 30 per cent for OTS) not acquainted with them. So it appears that part of the problem is to acquaint potential users of information with the existence of various sources and then to establish effective lines of communication between user and source.

Information Route: Source to User

A flow chart for information is given in Table I as it appeared in the Clyde Williams Report.[1] The route can be relatively direct and efficient, or it can have gaps that dead-end the information and keep it from the prospective user. Security classification of reports in which the materials information may not be classified can cause a dead end. Then there is the problem of proprietary information which, though necessary, causes considerable duplication of effort.

The position and function of information centers is evident from the flow chart. A new variety of technical expert—the information specialist—is now supplementing the talents of the very necessary trained librarians to man the technical information centers. Some information centers—notably the DMIC and the TPRC—carry on research and experimental investigations to supplement and check available information sources. This function of information centers very likely will become more important in the future as centers come to be known as authoritative sources of materials information.

Information Retrieval

A requirement in any large systematic collection of information is a means for ready access and correlation. Much has been written about the problems of information storage and retrieval, and much effort is going into the job of solving them. The National Science Foundation, in attempting to keep track of what is going on and to keep others informed, published a series of reports, two a year, on the subject "Current Research and Development in Scientific Documentation."

ASTM is also in the storage and retrieval picture and uses machine methods for spectral and X-ray diffraction data. For more on this see "ASTM and the Critical Data Problem" in the February, 1959, ASTM BULLETIN.

Typical Centers

DMIC.—The Defense Metals Information Center was established at Battelle Memorial Institute at the request of the Office of the Director of Defense Research and Engineering to provide Government contractors and their suppliers with technical assistance and information on titanium, beryllium, refractory metals, high-strength alloys for high-temperature service, corrosion- and oxidation-resistant coatings, and thermal-protection systems. Its functions, under the direction of the Office of the Secretary of Defense, are as follows:

1. To collect, store, and disseminate

technical information on the current status of research and development of the above materials.

2. To supplement established Service activities in providing technical advisory services to producers, melters, and fabricators of the above materials, and to designers and fabricators of military equipment containing these materials.

3. To assist the Government agencies and their contractors in developing technical data required for preparation of specifications for the above materials.

4. On assignment, to conduct surveys, or laboratory research investigations, mainly of a short-range nature, as required, to ascertain causes of troubles encountered by fabricators, or to fill minor gaps in established research programs.

The DMIC is an extension of the former Titanium Metallurgical Laboratory.

Thermophysical Properties Research Center (TPRC).—This center, established by Purdue University in 1957, is supported by a number of sponsors. The center will not only collect and file information from the literature but will also make critical comparisons and investigate where necessary to check the validity of data.

As the title of the center indicates, it is concerned with thermophysical properties for any and all materials—solids, liquids, and gases. Initial efforts of the center have been concentrated on seven properties:

Thermal conductivity
Viscosity (shear viscosity, Newtonian fluids)
Specific heat (at constant pressure)
Thermal emissivity, absorptivity, reflectivity
Mass diffusivity (Fickian diffusion)
Thermal diffusivity
Prandtl number

The choice of substance and property studied depends on the technical importance of the substance, the demand for the property, the paucity or abundance of the data, and finally on the degree of discord existing in a given area.

While special consideration is given to providing bibliographical and other information to the sponsors, information is also made available to nonsponsors. Profit-making organizations are charged a suitable fee; others, such as educational and nonprofit research organizations, are serviced without charge so far as resources of the center permit.

What Next?

It is now widely recognized that future technical advances depend to a critical degree on improvements in materials, and there is need for accelerating the process for acquiring information on materials. To do this we must team physicists with chemists with engineers—an interdisciplinary approach. Our national security depends on solving these difficult materials problems; thus it is likely that the Government will support this kind of research on materials on an ever broader scale. The need for such an interdisciplinary program in materials research was clearly stated in the Clyde Williams Report referred to earlier.

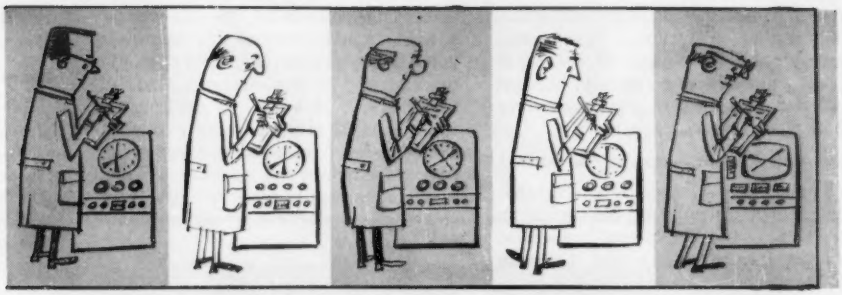
This kind of effort will further accentuate the information problem and make it even more necessary to systematize the collection and dissemination of information as it is being done in information centers.

Uraniborg—The First Research Institute

Art Gallery, Frederiksborg Slot, Denmark

TYCHO BRAHE (1546–1600), the famous Danish astronomer, was probably the first European to be endowed with liberal state funds for the pursuit of pure science. His King, Frederick II, granted him the little island of Hven, in the Sound just outside Elsinore, and gave him also enough money to build suitably and to maintain his work, himself, and his assistants. On the island, Brahe built Uraniborg (Castle of Astronomy), the first structure to be designed specifically to house scientists and their instruments. It contained laboratories and a library, as well as a series of observatories and dwelling quarters. In the grounds were an auxiliary underground observatory (protected from the high winds), a paper-mill and printing shop, an instrument maker's shop, and sundry other offices. It was started in 1576, ready by 1580, and much used by Brahe and a select group of "Research Fellows and Visiting Scholars" from all Europe until 1597, when the astronomer fell from grace and left his island for Prague. Shortly thereafter every brick was torn down by local inhabitants, and now only traces of the foundations are visible. This is a fine and accurate reconstruction, painted in oils by Heinrich Hansen in 1882; the original is in the Art Gallery of Frederiksborg Castle, Denmark.

Text by Professor Derek J. de Solla Price, Yale University. Copyright; text and photographs reproduced by permission of Professor Price and Arthur D. Little, Inc.



Plan for the Self-Qualification of Laboratories

By A. T. McPHERSON[1]

A plan is presented whereby objective standards can be established to enable a calibration or testing laboratory to rate itself with regard to: (1) the qualifications of its staff, (2) the adequacy of its facilities and equipment for the work undertaken, and (3) its performance in the periodic measurement or testing of "unknown" reference samples. Under the plan, standards would be set up in the specific fields in which the interest would be sufficient to warrant the expense of a reference-sample program. The standards would be established by one or more central, nongovernmental agencies in which the laboratories, their customers, and independent scientific experts would be equally represented. The laboratories participating in the plan would be authorized to report or publish their qualifications on a standard form.

A PLAN IS here presented whereby calibration or testing laboratories can determine their reliability in making precision measurements or their competence in the testing of products. The demand for some objective method for the qualification of laboratories comes from a variety of sources. In the first place, hundreds of new standards laboratories are being established in connection with missile and special weapons programs. Some of these laboratories are operated by Federal agencies, others by contractors, and still others by independent commercial organizations. All of these laboratories, however, feel at one time or another the need of some continuing means of independently checking the accuracy of their work.

Another group of laboratories are those engaged in testing products for qualification or acceptance by the Government or other large buyers. Here, some form of qualification is needed in the interest of both those who must contract for services on the basis of competitive bids, and those who are seeking business.

Still another group is made up of the laboratories of large industrial organizations which are concerned with the procurement of raw materials and the control of the quality of the finished product. The management of such laboratories needs some means of evaluating their performance in order that their services may be adequate but no more elaborate or expensive than necessary.

All of these needs can be met by a standard, centrally administered, self-qualification plan in each area in which there is need to ascertain the degree or state of competence of a laboratory.

Criteria for the Evaluation of Laboratories

Three major criteria determine the suitability of a laboratory for either product testing or calibration: (1) the qualifications of both the supervisory and the operating staff, (2) the facilities and equipment, and (3) the accuracy of the calibrations or tests performed as demonstrated by tests of reference samples. These criteria are not general, but must be related to specific calibrations or tests, and will change from time to time as the staff, facilities, and performance change. Hence, any evaluation of a laboratory must be a continuing process.

The magnitude of the task of evaluation, coupled with the absence of any agency—public or private—that is now constituted or authorized to undertake the rating process, makes it highly desirable to set up a general standard against which individual laboratories can measure their own qualifications for undertaking specific calibrations or test. Thus, the laboratories themselves, and not some independent agency, would, in effect, do the rating. The value of this plan would depend on the degree of objectivity with which the rating could be made.

Accordingly, it is the purpose of this paper to indicate some of the components that might enter into the rating and to establish that they could be made sufficiently objective to permit ready verification. Thus, in competitive situations prospective customers could satisfy themselves as to the qualifications of a laboratory for undertaking the work that they had in mind, and competitors could note and call attention to exaggerated or unwarranted claims that required correction.

Qualifications of Staff

The qualifications of supervisory staff could be rated in terms of academic training, length and level of professional experience, and publications and other evidence of scientific or technical accomplishment.

The qualifications of the supporting staff could be demonstrated similarly in terms of training and experience. The terms of employment would also be significant, since some laboratories hire technicians by the hour, as and when they have work to be done, whereas other laboratories employ supporting as well as professional staff by the year and thereby retain the advantage of specialized training and experience in the particular field of the laboratory.

Facilities and Equipment

The facilities and equipment required for product tests are usually covered in detail in the specifications under which the tests are being made. Calibrations necessarily require standards of appropriate type and accuracy, and these standards should be related through the minimum number of stages to the national standards. Thus, it would ordinarily be relatively simple to demonstrate the extent to which the facilities and equipment of any given laboratory

[1] Associate Director, National Bureau of Standards.

were adequate for particular calibration and testing operations. This would probably be the easiest of the three criteria to evaluate accurately, because most laboratories take pride in showing their plant and equipment.

Reference-Sample Tests and Calibrations

The actual performance of a laboratory as demonstrated by the testing or calibration of "unknown" reference samples consisting of either materials or test specimens would be the most critical measure of its capability of performing work in a given area. A reference-sample program, to be practical, would require a central organization and a sufficient number of participating laboratories to keep the expense within reasonable limits.

The central organization would prepare suitable specimens of undisclosed composition, dimension, or other pertinent characteristics and would distribute them at given intervals to participating laboratories. The laboratories in the program would make the requisite tests, measurements, or calibrations and report the results to the central organization by a specified date. At that time, the central organization would send to each laboratory the correct value and the limits within which the results should fall, if the work were done with reasonable skill and competence. The laboratory, not the central agency, would release the results in the qualification report described in a later section of this paper.

The reference specimens would be distributed at intervals of, say, one or two months. The cost of preparing and critically determining the composition, calibration, or other pertinent characteristics of the specimens would be defrayed by the participating laboratories on an annual basis to insure continuity of the program. Youden[2] has demonstrated that the distribution of specimens in pairs at two-month intervals may net much more information than single specimens at monthly intervals.

The selection of reference specimens should be such as to require the use of methods and techniques characteristic of the area in which qualification is desired. Where a number of laboratories are engaged in work on a single product, such as the testing of cement or the gaging of threaded components, the test specimen can be of the same product as that with which the laboratory is concerned. If, however, the laboratory is concerned with a range of products, such as ultra-high-frequency electronic components, the specimens would be chosen so as to be typical of the area. The number of different types of reference specimens required for the country as a whole would necessarily be large because of the scope and diversity of standardizing and testing operations to be undertaken. However, by utilizing to the maximum the specimens currently available from technical committees of national standardizing societies and the National Bureau of Standards, the time and expense could be kept within reasonable limits.

[2] W. J. Youden, "Graphical Diagnosis of Interlaboratory Test Results," *Industrial Quality Control*, Vol. 15, pp. 1-5, May, 1959.

Report of Qualifications

The report of qualifications would be presented on a standard form drawn up so as to give, as concisely as possible, the essential information about laboratory staff, facilities and equipment, and performance in the examination of reference specimens. Each laboratory would prepare and issue its own report and would be obligated to furnish proof of any statement that might be questioned. The specific design of the report form would require careful consideration so as to make it revealing and readily understandable by the customer, but not long or difficult to prepare.

Central Agency for Qualification

Inasmuch as the qualification plan is intended to be operated on a voluntary basis it is important that it be conducted by private initiative rather than by a government agency. Government agencies would, of course, be very much concerned, but their role would be one of cooperation rather than control.

The management of a central agency that might be established to implement the plan might be vested in a group made up of appropriately constituted representatives of the laboratories to be evaulated and those using the services of these laboratories together with independent, disinterested scientific experts. This group might be organized under the auspices of a recognized national standardizing society or association.

There would, of course, be a competent operating staff including experts in each major subject field and statistical engineers expert in the design of experiments and the interpretation of data.

Hitherto, national societies have avoided activities pertaining to the evaluation of laboratories because they did not wish to be concerned with subjective judgments or with the approval or disapproval of individual laboratories. However, they might be responsive to the present plan, because under the plan the central agency would be responsible only for administering the operation and collecting and collating factual information in accordance with recognized standard procedures. The only public release of the results of the evaulation of any laboratory would be made by the laboratory itself.

Cost of Operation

The cost of the operation would be defrayed by the sale of the reference specimens, inasmuch as the major item of expense would be their preparation and distribution. The principal sale of reference specimens would be to the laboratories on an annual subscription basis, but they would also be available to any users of laboratory services who might wish to make further tests of the performance of particular laboratories.

The amount that might be spent for the qualification of laboratories in any given area would, of course, be determined by the importance of reliability and accuracy in that particular area. There are many products and many types of measurements for which the expense of reference-sample programs could not be justified. On the other hand, there are products such as components of weapons that are so critical that it may be worth-while to spend much more than the cost of the item to insure that it has the correct dimensions or properties.

The real test of whether or not this plan or any plan for the qualification of laboratories is worth-while will be the willingness or unwillingness of those concerned to establish an effective organization for the purpose and bear the necessary cost.

Metallic Corrosion Congress to Be Held in London

THE FIRST INTERNATIONAL Congress on Metallic Corrosion will be held under the auspices of the International Union of Pure and Applied Chemistry in London on April 10–15, 1961. A Scientific Committee under the chairmanship of Mr. L. Kenworthy, present chairman of the Corrosion Group of the Society of the Chemical Industry, will organize the Congress. The program will comprise papers on any aspect of metallic corrosion. It is intended to devote much of the Congress to discussion of papers dealing with original work, but first-class, up-to-date review papers will also be included.

Preprints will be issued well before the Congress, and authors will be invited to introduce their papers briefly for discussion at the meetings. All papers, together with discussions, will be subsequently published in book form as the *Proceedings of the First International Congress on Metallic Corrosion:* London, 1961.

Inquiries should be addressed to The Hon. Secretary, First International Congress on Metallic Corrosion: London, 1961, 14 Belgrave Square, London, S.W.1.

District Activities

PITTSBURGH

President LaQue Presents Awards

EIGHT ASTM student membership prize awards were presented by President LaQue at a meeting of the Pittsburgh District, Wednesday, April 13. Recipients included:

James L. Martin and John J. Schreiber, The Pennsylvania State University; Stephen Veyo and Chester P. Smolenski, Carnegie Institute of Technology; Philip G. Meikle and John L. White, West Virginia University; and Samuel Klinvex and James D. Little, University of Pittsburgh.

Following the presentations, in which members of the District Council participated as sponsors of the students, President LaQue discussed "The Impact of Corrosion in Everyday Life." Drawing from his vast experience in the field, Mr. LaQue cited instances of corrosion around the home, in the automobile, in our tools and appliances. The principal factors influencing corrosion in each case and steps that may be taken to minimize the corrosion were discussed. Emphasizing that for the most part the average individual cannot control corrosion as well he might wish, Mr. LaQue concluded that the best approach to the problem is to insist on good starting materials.

The talk and presentation were part of the Pittsburgh District's annual President's Night, which permits members of the District and their wives to meet socially with the President. Chairman of the Pittsburgh District is Prof. J. P. Romualdi, Carnegie Institute of Technology.

Pittsburgh District Chairman J. P. Romualdi greets members of the District and their wives. At head table, left to right: E. J. Holcomb, District Vice-Chairman, Aluminum Company of America; Mrs. Holcomb; Prof. Romualdi, Carnegie Institute of Technology; ASTM President F. L. LaQue, International Nickel Co., Inc.; Mrs. Albert S. Orr, wife of the District Secretary.

CLEVELAND

What Are Automobiles Made of?

The many problems faced by materials engineers of the automobile industry were described by M. F. Garwood, chief engineer of materials, Chrysler Corp., at the March 30 Cleveland District meeting held at the new Cleveland Engineering and Scientific Center. Mr. Garwood cited typical examples of the many changes made in recent years to provide better automobiles.

The principal reasons for the greatly increased use of aluminum in automobiles since 1947 have been to reduce car weight, increase performance, and reduce costs. Mr. Garwood said the average amount of aluminum found in each of his company's 1960 cars amounts to almost 65 lb in 52 separate parts, replacing approximately 200 lb of iron and steel. Mr. Garwood reported that aluminum is readily adaptable to high production and low-cost automation and also provides savings because its weight reduces shipping and handling costs.

An example cited was the present transmission case and converter housing, a die-cast aluminum alloy which weighs 21 lb as compared with a 90-lb iron casting. Powdered metals also are now widely used in making many parts that formerly were forged.

Commenting on other automotive materials, Mr. Garwood said that one of the newer applications is the use of synthetic organic high polymers. These include rubber, plastics, and fibers for textiles. Plastics especially are increasing in use, he said.

The Cleveland District Council made student membership prize awards to ten students from the Cleveland area. Following a brief account of current activities and an explanation of the purpose of the student membership prize awards by ASTM Assistant Secretary Fred Van Atta, the students were introduced by District Chairman James H. Lansing. Awards were made to the following students from Case Institute of Technology: Howard E. Conlon, Wayne A. Hamilton, George T. Ikeda, and Donald R. Sherman, graduate students in the Department of Civil Engineering & Engineering Mechanics; and William R. Tuppeny, graduate student in the Department of Mechanical Engineering. Fenn College students receiving awards were: Peter W. Youngwerth, Joseph Gyure, Anthony Vaccariello, William Escher, and Lawrence Kreps.

Mr. M. F. Garwood (center), who addressed the March 30 Cleveland District meeting, is flanked by District Vice-Chairman A. G. Gray (left) and Chairman J. H. Lansing.

WESTERN NEW YORK–ONTARIO

Less Corrosion in Autos Predicted

"THE most useless thing I know of is reliable data which contradict common knowledge." So said ASTM President Frank L. LaQue in an address before a joint meeting of the ASTM Western New York–Ontario District, and the Western New York Section, American Chemical Society, at Niagara Falls, N. Y., on April 18.

Elaborating on his initial statement, President LaQue cited experiments which at first glance purported to show that salts used for clearing icy streets did not increase corrosion of automobiles. More careful examination of the experimental environment disclosed that sample tabs attached to taxis were washed every time the taxis were washed, while control samples had not been. Thus as

a result of this experiment there appeared to be no significant difference between the control samples and the experimental tabs. Conclusion drawn was that metal in contact with road salts would not corrode rapidly if washed frequently. "Experimental data which does not follow common knowledge, particularly in the study of corrosion, should be accepted skeptically," Mr. LaQue concluded. "We can explain results quite readily in the field of corrosion, but have some difficulty with our predictions."

Predicting that there would be less corrosion in the cars of the future, Mr. LaQue cited examples of progress on which he based his forecast: new anti-corrosion zinc coatings on surfaces not well ventilated; unit-body construction; better drainage (especially for door and fender panels); use of steels more resistant to corrosion; and better plating, including greater thickness and more coats of nickel and chromium.

Presiding at the meeting was Dr. Fred Whaley, Linde Co., newly elected chairman of the ACS Section. Charles Pope, Eastman Kodak Co., chairman of the ASTM District, represented the District Council at a dinner preceding the meeting.

Expansion of R & D Activity in Commerce Dept. Urged by Special NAS Committee

A TRIPLING OF U. S. Commerce Department funds for research and development and the appointment of an Assistant Secretary of Commerce for Science and Technology are being recommended in a report of a Special Advisory Committee of the National Academy of Sciences on "The Role of the Department of Commerce in Science and Technology" released in April. "Science and technology," said the report, "are playing an increasingly larger part in the industrial and business activities of the nation." The recommended expansion is needed to ensure that the Commerce Department can fulfill "its responsibilities in the progress of the nation's science and technology."

The committee recommends the establishment of an Office of Assistant Secretary of Commerce for Science and Technology to be filled by a man "with professional and management experience in science and technology." He would have responsibility for the Bureau of Standards, the Patent Office, the Coast and Geodetic Survey, the Weather Bureau, the Office of Technical Services, and cognizance of the science and technology activities of the Maritime Administration and the Bureau of Public Roads.

To provide the enlarged program, as well as the staff and the facilities to implement it, the committee recommended that the Department's 1959 operating budget of $22 million for research and development be doubled as soon as the funds can be effectively used, and that it reach an eventual level of some $75 million.

In thanking the committee for its valuable services, Commerce Secretary Frederick H. Mueller stated that "some of the budgetary increases and program expansions which it proposed already have been effected by us or are recommended in our . . . budget now before the Congress. One in particular is an entirely new ultramodern plant for the National Bureau of Standards in Gaithersburg, Md. Initial appropriations for planning were requested by us and granted by Congress last year. This year's FY 1961 budget requests $23.5 million to start construction. When completed, the layout will be one of the finest units of government laboratories in the world."

This is one of a series of photographs from a collection compiled by Prof. Jasper O. Draffin and displayed in the Arthur N. Talbot Laboratory, University of Illinois.

ALEXANDER LYMAN HOLLEY (1832–1882). Born in Connecticut, Alexander Holley became a mechanical engineer of remarkable ability. Energetic, persistent, and inventive, he sought "convenient means" of doing work. He improved many kinds of machinery, but his life work was the making of steel. Holley was responsible for the early development of the Bessemer process in this country, and at Troy, N. Y., he made the first commercial Bessemer steel in the United States.

"There is a small but most truly scientific and most truly practical school of philosophers whom we may designate as original investigators—men who come close to nature, who search into first principles, and who follow in all things that scientific, and therefore fruitful, method by which the relations of matter and force are discovered, classified, and brought within the reach of practice. These wonderful men do not indeed create the laws of nature, as they sometimes almost seem to, but they go up into the trembling mountain and the thick darkness, and bring down the tables upon which they are written."

Technical Education

Technical Committee Notes

Sun and Laboratory Exposure Data Presented

CULMINATING an extensive exposure program to evaluate fading characteristics of leather, both outdoors in South Florida and under several laboratory conditions, the ALCA-ASTM Joint Committee on Leather presented a complete report of the findings at its meeting in Philadelphia on March 17. Dr. Robert Stubbings reported fading data for 13 different leathers in terms of Langleys and sun hours for outdoor exposures and for four different types of Fadeometers and the Hanovia lamp. In terms of relative change in three dimensions of the Hunter color solid, conditions causing the greatest to the least amount of change per unit time were, in order, sun hours, Langleys, Fadeometers, and the Hanovia lamp. Data on average, standard deviation, and coefficient of variation were given for the R_d scale (lighter, darker) for the a scale ($+a$ redder, $-a$ greener) and the b scale ($+b$ more yellow, $-b$ more blue).

This extensive exposure program will be summarized for publication, and it is planned to deposit all the exposure data for reference in the ASTM Research Reports repository. Objective of the program is to develop a laboratory test that can be used for evaluating fading properties of leather and which will have some degree of correlation with outdoor exposure.

Certain other factors relating to the stability of leather under various deteriorating influences were covered in a special meeting of the Deterioration Section. Reports were presented on interlaboratory studies of perspiration resistance, heat stability, and dry-cleaning and laundering.

There is considerable interest in relating the water absorptive and transpiration properties of leather to comfort when leather is used in shoes and clothing. This subject occupied much of the attention of the Research Subcommittee, which plans to prepare a statement on evaluating comfort properties of leather for consideration by the new ASTM committee on Psychophysical Testing now being organized. Also, in this connection, the committee has studied several methods for determining thermal conductivity of leather. Attempts are being made also to relate this property to comfort.

Officers elected for the next two-year term, beginning after the Annual Meeting are: chairman, J. Naghski; vice-chairman, B. L. Lewis; and secretary, Milton Bailey. The committee also elected the following members-at-large for the Executive Committee: B. G. Ashcraft, M. M. Baldwin, M. H. Battles, Robert Stubbings, and R. L. Young, Jr.

Recommended Practices for Infrared, Ultraviolet Analyses, To Be Published as Tentatives

Publication as tentative of recommended practices for general techniques of infrared quantative analysis and recommended practices for general techniques of ultraviolet quantitative analysis was recommended at the meetings of Committee E-13 held on March 1 in Pittsburgh, Pa., in conjunction with the Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy. Intensive study of these methods since their publication for information only in June, 1959, has shown need for only minor changes before these recommended practices are advanced to tentative status. Reference to these recommended practices in absorption-spectroscopy test methods should considerably reduce the detailed instructions that otherwise must be repeated in those methods.

The coverage of published absorption spectral data by the Wyandotte–ASTM punched-card index is rapidly being brought up to date. This index is now being prepared at Wyandotte Chemicals Corp. under the sponsorship of Committee E-13 for distribution by ASTM. Availability was announced of a new (seventh) supplement to the infrared spectral data index, a new (third) supplement to the infrared formula-name index, and the first supplement to the ultraviolet empirical formula-name index. Plans are under way to issue indexes to spectra in the near-infrared and visible ranges.

Symposia on analytical applications of nuclear magnetic resonance and theory and instrumentation in molecular fluorescence spectroscopy were sponsored by Committee E-13 at the Pittsburgh conference.

Sensory Evaluation is Subject for New Committee E-18

A NEW ASTM COMMITTEE E-18 on Sensory Evaluation of Materials and Products will be organized early in October, with the following scope as recommended by the Steering Committee and approved by the Board of Directors:

The promotion of knowledge, stimulation of research, and the development of recommended principles and practices for the sensory evaluation (including discrimination and preference) of materials and products.

These aims shall be furthered by:

1. Cooperation with other committees of the Society and with other organizations.
2. Preparation of standard definitions and nomenclature.
3. Establishment of principles of psychophysical test methods.
4. Preparation of recommended practices for design and conduct of tests, collection of data, and analysis and interpretation of results.
5. Fostering study of relationships between sensory evaluations and physical and chemical measurements.
6. Dissemination of information by technical publications and symposia.

The following subcommittee structure will be recommended at the organization meeting:

Advisory Subcommittee
Subcommittee I on Definitions, Nomenclature, and Editorial
Subcommittee II on Principles of Psychophysical Test Methods
Subcommittee III on Preparation of Recommended Practices
Subcommittee IV on Instrumental-Sensory Relationships

Amos Turk, odor consultant, of Danbury, Conn., has been designated by

the Board of Directors as temporary chairman. While the Steering Committee agreed that there should be no limitations on the total number of members, nevertheless membership should be open only to those who can make technical contributions to the committee's work. Expressions of interest in participating in this activity are welcome and should be addressed to ASTM Headquarters.

Plastic Foam Makers Now Have TDI, POPG Specifications

Final approval by Committee D-20 on Plastics of a new specification for toluenediisocyanate (TDI) and polyoxypropylene glycol (POPG), effected at its March meeting in Cincinnati, will aid urethane foam producers in control of quality of two of their most important raw materials. Developed in cooperation with the Society of the Plastics Industry, the new specification will appear in the Committee D-20 Annual Report preprint available next month. The specification covers three types of TDI and one type of POPG. The three types of TDI differ only in their isomer ratio and are designated in terms of the percentage of 2,4-isomer with remainder of the 99.5 per cent pure material as the 2,6-isomer. Type I is 97.5 per cent 2,4-isomer, Type II 80 per cent, and Type III 65 per cent.

The above action was one of many taken at the Cincinnati meeting. Subjects covered by some of the 12 new tentatives proposed by the committee: new tests for brittleness temperature of plastics films; methods for viscosity measurements; new specifications for rigid PVC and ABS plastics and PVC plastics sheeting; specifications for styrene-butadiene compounds, for epoxy resins, and for woven glass fabric for reinforced plastics. The committee also completed work on a new recommended practice for determining the degree of exposure of plastics to artificial weathering conditions. This method employs a specimen of acrylic plastic containing a special fugitive dye which has fading characteristics that depend on the degree and amount of exposure. This practice can be used to correlate laboratory weathering with outdoor exposure by using standard fading specimens under both exposure conditions.

Reinforced Plastics Work Expands. Very large structures are often made of reinforced plastics, and with this type of structure it is difficult or expensive to sample the material by cutting pieces out of the structure. Needed is a reliable way to assess the properties of the structure without destroying it. Recognizing this problem, the committee established a new section on inspection and nondestructive testing. There are also occasions when it is necessary to cut specimens from a structure, and the procedures for handling this problem will be under another new section on sample preparation. A third new section will cover preimpregnated and premixed materials.

Connor Presents FHA Plastics Problems. Mr. Neil Connor, head of the Architectural Standards Division of the Federal Housing Administration, outlined to a special meeting of the committee the problems of the FHA in insuring houses against premature failure of the structure and its components. He pointed out that while many plastics have found favor in housing construction and are giving good service, there are others which, for various reasons, have failed. He urged the committee to establish standards for plastics materials and products that can be the basis for both the adoption of these materials in building codes and for approval for FHA loans.

This whole subject of plastics in building and the problem of developing adequate standards is under active consideration in the executive group of the plastics committee. A full discussion of the subject is scheduled for the June meeting.

Statistical Approach to Specifications. Dr. William R. Pabst, Jr., chief statistician of the Bureau of Naval Weapons and a member of Committee E-11 on Quality Control, spoke to the plastics committee about expanding the use of statistics in specification problems. Dr. Pabst told about the work of Committee E-11 and suggested ways in which the plastics committee could profit from this work. Dr. Pabst's talk was the fourth in a series of indoctrination lectures on statistics sponsored by the committee.

The committee elected the following officers to serve for the next two years, beginning after the Annual Meeting this June: J. B. DeCoste, chairman; Paul E. Willard, vice-chairman; John Hanna, 2nd vice-chairman; Henry Gunst, membership secretary; and Charles F. Ferraro, recording secretary.

New Specifications Coming for Limestone, Sandstone

A MAJOR step was taken in the development of specifications for the five most common natural building stones at the meeting of Committee C-18 on Natural Building Stones held in Washington, D. C., on March 25. With tentative specifications for structural granite (C 422) and for roofing slate (C 406) already published, as well as a proposed specification for marble for exterior use published as information only, drafts of proposed specifications for limestone and for sandstone were reviewed. The proposed specification for exterior limestone includes requirements for composition, structure and texture, classification, and such physical properties as crushing and transverse strength, porosity, absorption, apparent specific gravity, color, and abrasive resistance. The proposed specification for exterior building sandstone includes selection, sampling, and testing requirements as well as physical properties similar to those for limestone. Final drafts for committee action are expected this year. Outgoing Chairman L. W. Currier presented a very interesting and thoughtful résumé of the work that should be done by the committee. In addition to completing the series of standard specifications for exterior stones, the committee should develop specifications for interior finish stones and finishes as well. He proposed that a study group be formed to review the scope and further interest of Committee C-18. The greatest current problem is to establish a means of evaluating the durability of stone for exterior use. The gap between actual performance in use and in laboratory tests has not yet been bridged. There is need for further definitions and nomenclature which should include textural terms as well as commercial forms of stones such as cut-stone, ashlar, rubble, and others. Sampling in this field is possibly a more difficult and complicated procedure than with other natural materials. At present, the consumer must generally rely on the integrity of the producer.

The newly elected chairman of Committee C-18 is W. W. Key, U S Bureau of Mines. Incumbent Vice-Chairman T. I. Coe and Secretary F. S. Eaton were re-elected.

Staining, Foaming, Corrosion Engage Antifreezes Committee

COMMITTEE D-15 on Engine Antifreezes, at its April 5 meeting in Washington, D. C., received the report of an interlaboratory study to provide data for a proposed procedure for determining the effect of commonly encountered staining agents on organic finishes. Three automobile manufacturers supplied test panels of eight different finishes and colors for the study, which were subjected to ten different solutions. The data show that considerable progress has been made toward establishing a test procedure.

Interlaboratory studies show that enough progress toward a standard foaming test of engine antifreezes has been made that a recommended standard may be ready next fall.

Collaborative studies to improve the glassware corrosion test, Method D

1384, and studies to establish the effect of antifreezes on rubber hose were reported and discussed. The data from the hose burst test show considerable variation, and a revised approach will be subjected to a new interlaboratory study.

How Long Can Shipping Containers Be Safely Stacked?

AVAILABLE data on stacking load performance of shipping containers were reviewed by Committee D-10 on Shipping Containers in Atlantic City, April 5. This information will serve as a basis for a recommended practice for safe stacking life of shipping containers. This practice will contain a condensation of the considerable work on stacking completed at the U S Forest Products Laboratory, and will explain the variables to be considered in determining stacking life of shipping containers: shock-loading, eccentricity of loading, vibration, atmospheric conditions, length of time, and dead load.

Work is continuing on instrumentation for determining the dynamic properties of package cushioning materials (D 1596). New cushioning materials continuously being developed call for further refinements in measurement techniques. The committee is particularly interested in hearing from research workers in this field. Those using electronic devices to measure impact, vibration, or shock in connection with any type of material are urged to get in touch with K. Q. Kellicut, U S Forest Products Laboratory, Madison, Wis.

The considerable interest in tests for interior packing materials has encouraged development of tests for materials for exterior use on the shipping container. Accordingly, a new Subcommittee on Exterior Packing has been formed. The first area of interest is in tapes, including reinforced, antiskid, pressure-sensitive, and glued tapes.

Data from persons having considerable experience with the shipping container tests for vibration (Method D 999), incline impact (Method D 880), and water vapor resistance (Method D 1008) were evaluated for possible future revision of these methods.

New Wood Adhesives Subcommittee Surveys Its Field

AT THE spring meeting of Committee D-14 on Adhesives, in Philadelphia, Pa., on April 1, the new subcommittee on wood adhesives presented a series of discussions to review the current status of research and testing in this field as a basis for standard methods. Discussions covered particle board binders, wood adhesive research using cross-lap specimens, proposed revisions in the block-shear (D 905) and the plywood-shear (D 906) tests, preparation of wood surfaces for gluing, and estimation of wood failure in standard tests.

Recent work on metal-to-metal adhesive testing was also presented covering lap-shear, creep, high temperature, and peel testing, as well as metal surface preparations for adhesives for nondestructive investigations.

Proposed tests of flooring adhesives include strength in tensile shear, resistance to warm soap solutions, and temperature resistance. Consideration is being given to the preparation of standard concrete test slabs for use as substrates in evaluating tile adhesives and also a method of determining the amount of moisture in concrete slabs.

Other new methods presented for committee action include: a recommended practice for defining the conditions for the exposure of adhesive specimens to high-energy radiation before testing, and outdoor weathering of adhesive bonded structures. Completed specifications include those for poly(vinyl acetate) emulsion adhesives, and adhesives for sealing top flaps of shipping containers.

Flexible Barrier Seal Strength Test Being Revised

REVISIONS to the proposed method of testing the seal strength of flexible barrier materials were presented to Committee F-2 on Flexible Barrier Materials at its meeting in Atlantic City, April 7. These include various impact tests, such as the pendulum and the dart-type. Methods for clarity, and water and gas transmission were also discussed; these tests are being developed in cooperation with other ASTM committees.

Chemical tests used in the flexible barrier field have been collected for review and possible standardization. Interest was shown in methods for extractable materials in flexible barrier materials. Existing methods for extraction will be presented at the next meeting.

The first step toward performance specifications is being taken by assembling a complete list of all flexible barrier properties and locating existing methods to cover them. This survey will serve as a basis for the development of specific test methods.

New Subcommittee Setup for Asbestos-Cement Committee

A MAJOR reorganization of committee structure was approved at the meeting of Committee C-17 on Asbestos-Cement Products held in New York City on February 17 and 18. Subcommittees formed according to type of product will replace the present subcommittees, which were established at the time of the organization of the committee 14 years ago. The new subcommittees:

Technical Committee Notes

Executive Subcommittee
Subcommittee I on Nomenclature and Editorial, W. A. Heausler, chairman
Subcommittee II on Research, William Lerch, chairman
Subcommittee III on ISO Technical Committee 77, Asbestos-Cement Products, J. R. Cran, chairman
Subcommittee IV on Roofing and Siding, F. Crippen, chairman
Subcommittee V on Flat and Corrugated Board, S. E. Williams, chairman
Subcommittee VI on Pipe, C. R. Meek, chairman

The determination of the organic fiber content of asbestos-cement products is now covered in a new tentative method of test accepted for recommendation to the Society. A proposed method of test for uncombined calcium hydroxide, to replace the alkalinity test now prescribed in the ASTM specifications on asbestos-cement pipe (C 296 and C 428), is under consideration.

The first group of some 50 definitions of terms relating to asbestos-cement products was reviewed and accepted, subject to letter ballot. The committee approved a move to separate all methods of test from specifications and to combine them under a separate ASTM designation. As a result, the committee will recommend (1) separate proposed methods of sampling and testing asbestos-cement flat sheets, roofing and siding shingles, and clapboards and (2) methods of testing asbestos-cement pipe. The methods of test for evaluating corrugated asbestos-cement board, however, remain in the specification for this material (C 221).

C-16 Studies Research Program on Reflective Insulation

THE use of reflective insulation in the atomic field presents an interesting area of research to Committee C-16 on Thermal Insulating Materials, as discussed at its meeting in Charleston, S. C., on March 8–10. A proposed research project, if approved by the committee, will be presented to the Administrative Committee on Research bearing the title "The Effectiveness of Reflective Insulation in Gaseous Environments of High Temperatures and High Pressures." This is a basic research program on the use of reflective insulation in nuclear reactor chambers, in afterburners of jet engines and missiles, as well as inside vessels used in the chemical field.

Steps were taken to implement the new philosophy of specifications based on establishing the requirements of properties of thermal insulation by type rather than by composition and generic terms. Systems of classification are be-

ing studied whereby products will qualify according to their ability to meet the properties established.

The scope of the committee will be broadened to include coverings used to preserve the thermal insulating efficiency of coating materials.

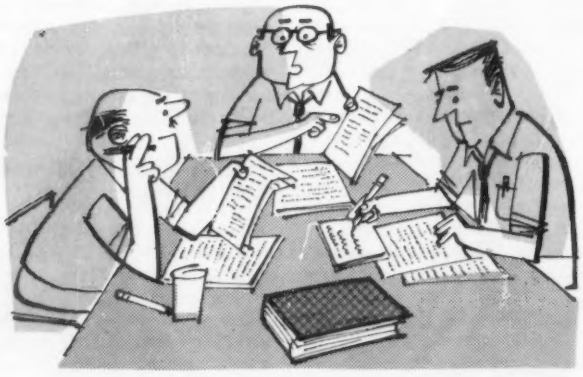
A need for determining thermal conductance and transmittance at low temperatures down to 0 F has led to formation of a task group to investigate the use of the present guarded hot box method (C 236) at these low temperatures. In line with a need for so-called "quicker" methods for determining thermal conductivity, as requested by other ASTM technical committees, a round-robin test program will lay the groundwork for a method of test using the thermal conductivity probe. The heat meter conductivity apparatus will also be studied.

Determination of water absorption of preformed block-type thermal insulation is the subject of a proposed method of test now being circulated in the responsible subcommittee. This procedure does not apply to high-temperature block and pipe insulations above 212 F. A recommended practice for cutting beveled blocks for pre-formed thermal insulation is also under study. The subcommittee concerned with loose-fill insulation is attempting to standardize a method of test for determining density of materials in this category. Thermal stability of coatings for thermal insulation will be determined by a proposed method of test which is ready for committee approval.

In Defense of Committees

(And, egad, it's about time!)

By ROBERT BURNS[1]



NEXT TO the bubonic plague and the seven-year itch, committees rank as the world's greatest menace. Nadir El Hif, noted rocket expert, in testimony before a special committee of the Doughnut-Hole Cutters' Union 747 stated flatly that we would have a man in outer-galactic space right now if it weren't for interference by committees. His Highness, King Horatius Applecore, speaking for his little principality of Outer Euremia, reported that crimes of violence by children 2.4 years of age had increased 84 per cent for 1959 over 1958, all due to his Prime Minister's "dependence on committees." J. Harold Baldpate, famous hair stylist who follows the humanistic sciences as a hobby, stated unqualifiedly that committee meddling was entirely responsible for the population explosion in underdeveloped nations.

Some of our most distinguished scientists have expressed condemnation of committees by more precise evaluation than used by lay leaders. Professor Archie Hopalong, originator of the Hopalong Hypothesis, measures committees by the scale of intelligence. The average committeeman, he reports, has an IQ of 21 (give or take a point or two). In a recent address to the Wisconsin Commission of Deputy Sewer Pipe Inspectors, he stated the situation succinctly: "If there is no intelligence, can stupidity be far behind?"

On the other hand, the Thipplehoof Theorem uses the number of committeemen as the basic consideration. According to Herr Thipplehoof, who plots effectiveness against numbers, the ideal committee consists entirely of one man who does all the work. The rest sit around discussing airplane schedules, genius-type grandchildren, and the hole-in-one they made last summer (unfortunately there were no witnesses). These, he theorizes, should not be counted as committee members but as foggy ectoplasms of the fourth order, composed of low-voltage domains in negative protons.

Perhaps the most scientific approach is the Papadoupilas Postulate using Hassenrfsffer's 22nd law of quantum mechanics. When the good Professor Papadoupilas wants to measure a committee for effectiveness, the operation is simple. He constructs a quaternary mathematical model, cranks it into the IBM, takes one look at the emerging tape and says: "This Committee ain't no good either."

Now, underneath all this joking about committees, there is a serious substrate, a growing concern about the committee system, its cost to the sponsors, and the good of it, if any. Our time is taken up more and more with committee work, and when we observe an ineffective committee more criticism is added. Warren Weaver, in an ostensibly facetious article in *Science*[2] has outlined a typical report by a typical committee. The piece is delightful reading, but only thinly disguised is the underlying criticism by one of the most distinguished of our scientific community.

The trouble, of course, is obvious. We ask committees to perform functions for which they are pathetically unsuited. In this history of the world, no committee has made an important discovery of nature's secrets, or has invented anything, or has engineered anything, or produced anything; yet, we continually ask them to do these things, knowing full well they will fail. So let's not blame committees, blame instead the naive folks who ask them to do impossible jobs.

A few years ago, in one of Frank Tatnall's little publications, there was a brief historical review of strain-gage development. It seems that in the early days, when a strain gage was a new and fascinating laboratory gadget, but of enormous potential, it was decided that this little gimcrack must not grow up like Topsy but must have a planned future. Accordingly, committees were formed to run the Whole Business in an orderly and well-disciplined manner. Well, the little gadget did grow up, in fact grew into a new scientific area of stress analysis, but the committees were still so busy with the General Plan, so

(*Continued on p. 59*)

[1] Executive Secretary, Materials Advisory Board, Division of Engineering and Industrial Research, National Research Council.

[2] Warren Weaver, "Report of the Special Committee," *Science*, Vol. 130, No. 3386, Nov. 20, 1959.

Rheological Testing of Elastomers at Low Temperatures. Part II*

By L. BOOR, M. HANOK, F. CONANT, and W. SCOVILLE, JR.

Results are given from a cooperative study to determine the extent to which certain superposition principles are applicable to analysis of different types of deformation of elastomeric materials. Briefly, these principles are: (1) recovery rate from an equilibrium deformation after removal of a given load is equivalent to the creep rate from zero deformation upon application of that load and, (2) creep, recovery, or stress relaxation curves obtained at different temperatures can be pieced together into a continuous curve of time *versus* deformation or stress. Both principles are predicated on the use of an essentially equilibrium deformation or stress as a base from which the percentage change with time is calculated.

The first of the above principles was demonstrated for both torsional and shear deformations, but not for tensile deformations, possibly because of some inaccuracy in the test method. The second principle was demonstrated for shear creep, shear recovery, torsional creep, torsional recovery, and tensile stress relaxation. Applications of this method of analysis are given to show how the rheological behavior of an elastomer at a given temperature may be predicted for very short or for very long periods of creep, recovery, or stress relaxation from measurements made at a series of temperatures.

THE Low-Temperature Correlation Section of Subcommittee 27 of ASTM Committee E-1 on Methods of Testing, established in March, 1951, has published reports of its work (1–4).[1] The present paper describes additional work performed as a result of the conclusions reached in the work on rheological testing (3). It appeared that of the various test procedures studied, shear recovery (method I) offered some promise of an approach that would characterize an elastomer in respect to its rheological response at low temperature.

The basic theory is presented by Conant, Hall, and Lyons (5). In brief, it is based on the demonstrated equivalence (measured by shear stressing) of creep and recovery at a given temperature and the extension of this concept into a continuous relationship between time, temperature, and rheological behavior.

The principle states that an elastomer under load at a certain temperature will attain a certain percentage of its equilibrium or ultimate strain at that temperature in a certain time; conversely, at this same temperature and time, it will recover the same percentage of its equilibrium strain when unloaded from a condition of equilibrium strain. It is to be noted that while the value of strain can be varied over a wide range, the percentages of creep or recovery will be nearly the same. The original paper demonstrates this equivalence for Hevea, styrene-butadiene rubber (SBR), neoprene, butyl rubber, and butaprene formulations. Plotting creep (or recovery) as per cent against log time gives curves which characterize the various polymers.

All of the original data were obtained on specimens subjected to shear stresses. This method involves preparation of special test specimens consisting of a double sandwich in which the elastomer is vulcanized to separator plates, and a special stressing and strain-measuring

LADISLAV BOOR, chief, Instrument Section, Technical Division, Military Clothing and Textile Supply Inspection Agency, U. S. Army Quartermaster Research and Development Division, Philadelphia, Pa. Mr. Boor received his B.S. Chemistry from The Pennsylvania State University and has been with New Jersey Zinc Co. doing work on quality control of nitrocellulose plastics; American Cyanamid Co. as physicist, testing laboratory; and American Instrument Co. as development engineer.

MAX HANOK has been engaged in elastomer research at the Elastomers Development Section, Material Laboratory, New York Naval Shipyard, since 1950. His chief interests have been in the studies of adhesion, and of rheological properties at low temperatures, and in the development of a method for determining crystallization rates and cure based on dielectric relaxation.

F. S. CONANT has been engaged in physics research at the Chemical and Physical Research Laboratories of The Firestone Tire and Rubber Company, Akron, Ohio, since 1943. One of his major fields of interest has been in the field of low-temperature properties of elastomers on which he has had a number of publications.

W. E. SCOVILLE, JR. graduated from Stevens Institute of Technology as a mechanical engineer in 1934 and joined U. S. Rubber Co. the same year. After serving as assistant development manager for the Passaic plant until 1958, Mr. Scoville joined Boston Woven Hose and Rubber Co. of Cambridge, Mass., as technical director.

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* The opinions and assertions in this paper are the authors' and are not to be construed as official or reflecting the views of the Armed Services or of the industrial laboratories concerned.

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

apparatus. Correction for the Gough-Joule effect is inherent in the method of expressing deformation at a particular time as a percentage of the equilibrium strain or complete recovery at the given temperature.

Since the apparatus for testing in shear is somewhat complicated and not commonly available, the question presented itself of the possibility of measuring the same type of behavior under other forms of stress such as tension or torsion, apparatus for which is more widely available.

It was decided to investigate the problem by assigning to various collaborators certain subdivisions of the work, on a basis of their specialized equipment and experience.

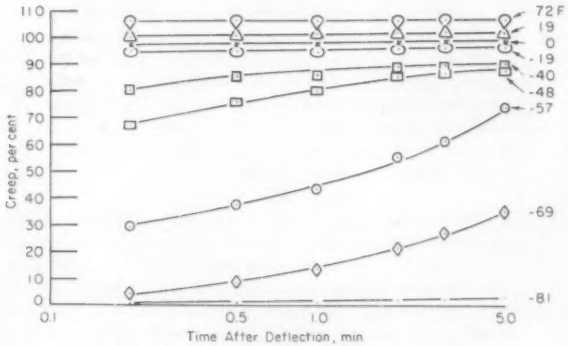


Fig. 1.—Torsional creep of Hevea compound.

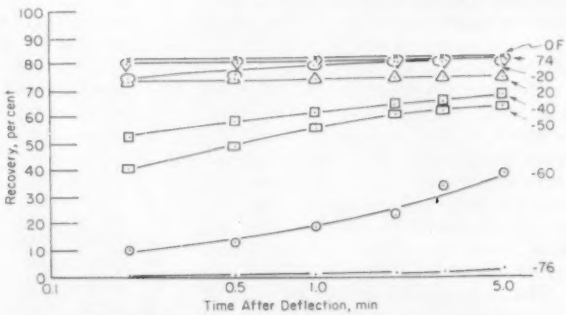


Fig. 2.—Torsional recovery of Hevea compound.

The various phases of the work were performed by the following laboratories:

1. Shear creep and relaxation—Firestone Tire and Rubber Co., Akron, Ohio, under direction of F. S. Conant.
2. Tensile creep and relaxation—United States Rubber Co., Passaic, N. J., under direction of W. E. Scoville, Jr.
3. Torsional creep and relaxation and stress decay—Naval Materials Laboratory, New York Naval Shipyard, Brooklyn, N. Y., under direction of C. K. Chatten and Max Hanok.
4. Correlation of results—Philadelphia Quartermaster Depot, U. S. Army, under direction of Ladislav Boor.

All compounds were prepared by Mr. Scoville, so that all laboratories were testing the same material. In addition, all test specimens except for those to be used in the shear test were prepared by Mr. Scoville, so that states of cure were uniform. The compounds used were the same Hevea gum and SBR tread-type stocks as those used in the paper by Chatten (3).

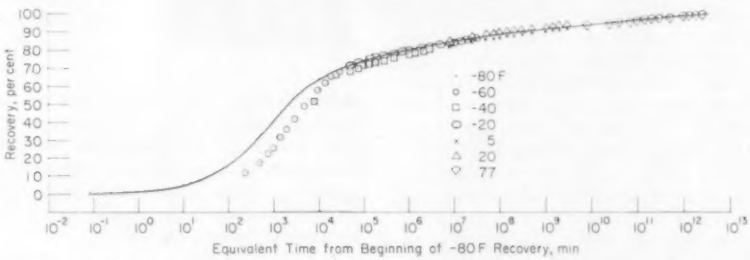


Fig. 3.—Time-temperature relationship from shear recovery of Hevea compound.

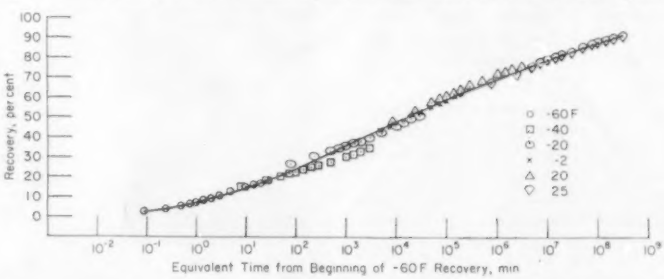


Fig. 4.—Time-temperature relationship from shear recovery of SBR compound.

Experimental Procedure

The experimental procedure involved two phases for all forms of stressing. In the first phase, the equilibrium strain in shear, tension, and torsion and the equilibrium stress in tension was determined after an initial deflection of the specimen at 74 F, and after the subsequent reduction of the temperature to 20 F, 0 F, −20 F, −40 F, −50 F, −60 F, −70 F, and −80 F. The specimen was maintained in a deflected position throughout the entire procedure. This deflection of course increased with decrease in temperature for the creep determinations and was held constant for the stress determinations. Values were determined 10 min after deflecting the specimens at 74 F and 10 min after achieving thermal equilibrium at each of the succeeding lower test temperatures.

In the second phase of the experimental work, the creep and stress relaxation values were determined at intervals of 0.2, 0.5, 1, 2, 3, and 5 min after the initial specimen deflection at the lowest test temperature at which a required deflection could be produced. This was followed by determinations at the same time intervals at each of the succeeding higher temperatures used in the equilibrium determinations, up to and including 74 F. The specimens were conditioned for 10 min in the undeflected state at each of the test temperatures before applying a fixed load or a fixed strain for the determination of deflection or stress during the 5-min period. The deflected specimens were permitted to return to an assumed zero deflection by removing all of the deflecting force and then proceeding to the next higher temperature.

Method of Plotting Continuous Time-Temperature-Rheological Property Curves

The creep and recovery data, obtained using the shear, torsional, and tensile methods, and the stress relaxation data, obtained using the tensile method, were plotted as families of curves of per cent rheological property as a function of log time, as shown in Figs. 1 and 2. The ordinates in the creep and stress relaxation curves represent percentages of the equilibrium values determined at the indicated temperatures. The ordinates in the recovery curves represent percentages of the deformation recovered after unloading at each of the indicated temperatures.

The families of curves were then plotted as continuous functions of time, temperature, and rheological property in the manner described by Conant *et al* (5) for shear creep and recovery, and by Tobolsky (6) for stress relaxation. In effect, the method consists of end-to-end joining of the families of curves in a given plot as those in Figs. 1 and 2 into a continuous curve of the type shown in Figs. 3 and 4, with the lower temperature portions of the curve appearing at the shorter log time intervals. The time scale of the composite curve, which consists of adjacent or overlapping 10^{-1} to 10-min periods, is made continuous by starting the time at which values are available at 10^{-1} min and naming each of the succeeding log cycles in increasing powers of 10.

The method of plotting the continuous curves involves the assumption that if a continuous relationship exists, then discontinuities in the composite curves indicate the lack of data over a particular temperature range, while identical values determined at two succeeding temperatures indicate an identical relationship. Accordingly, in order to eliminate discontinuities in plotting the composite curves, one or more log time cycles were placed between plotted points, as required, and the curve was continued through these cycles. An example is seen in Fig. 5 in which a time cycle was added in the time interval 10^6 to 10^7 min. On the other hand, the much more common occurrence was the appearance of nearly equal values at succeeding test temperatures. These points were overlapped by making the 1-min to 10-min cycle of one temperature identical with the 0.1-min to 1-min cycle of the next higher experimental temperature. In Fig. 6, for example, the 2-min and 5-min values at −48 F are nearly coincidental with the 0.2-min and 0.5-min values obtained at −40 F.

Details of Each Procedure

Shear Creep and Recovery

The apparatus consisted essentially of a means of applying shear stress to a double sandwich-type specimen so that observations could be made of the specimen deformation as the test conditions were varied (1). Each half of the sandwich was $\frac{1}{4}$ by $\frac{3}{8}$ in. cross-section and $3\frac{3}{4}$ in. long. In performing a recovery test, the specimen was allowed to remain under 80 lb (28.5 psi) load for 16 hr at room temperature and then cooled to −80 F while still under load, thus producing essentially a state of equilibrium deformation. The load was then removed and the progressive recovery was noted for 30 min, after which the load was reapplied and the specimen temperature was raised to the next higher temperature. Another recovery reading was obtained and then the test was repeated at still higher temperatures.

The shear specimens were adhered to steel end and center plates by a curing-type adhesive. Loxite[2] 3000 was satisfactory for both Hevea and SBR. Difficulties of clamping the specimen during the test were thus reduced to a minimum. The long, thin shape was chosen so that the deformation under load would approach pure shear. The principal difficulty associated with the use of a shear deformation is that of specimen preparation. A special mold designed to hold the metal inserts is required, the inserts must be thoroughly cleaned and masked, the proper adhesive applied and a conditioning time before curing must be allowed.

A diagram of the essential parts of the apparatus is given in Fig. 7.

Composite curves showing recovery from equilibrium shear deflection are given for Hevea in Fig. 3 and for SBR in Fig. 4. Experience has shown that these curves would be duplicated by results showing percentage creep from zero deformation.

Tensile Creep and Recovery

The apparatus used was the regular temperature-retraction (T-R) instrument used in ASTM Method D 1329[3] and illustrated in Fig. 8. The only modification was the use of an extra

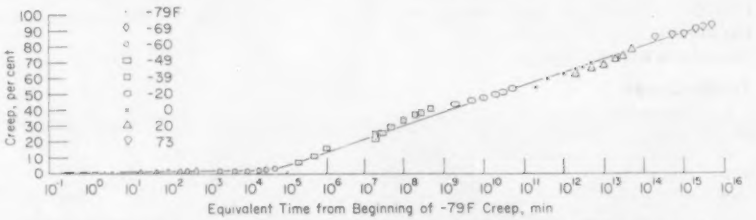


Fig. 5.—Time-temperature relationship from torsional creep of SBR compound.

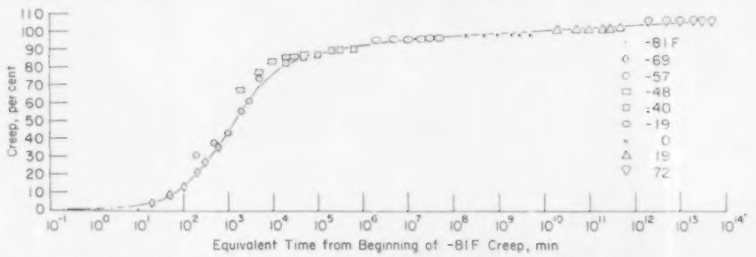


Fig. 6.—Time-temperature relationship from torsional creep of Hevea compound.

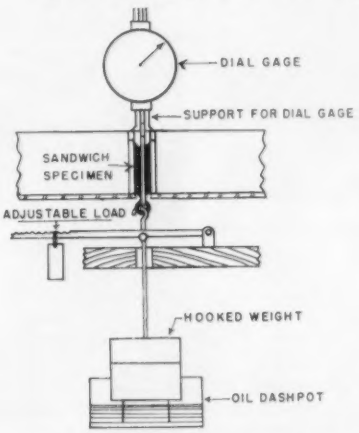
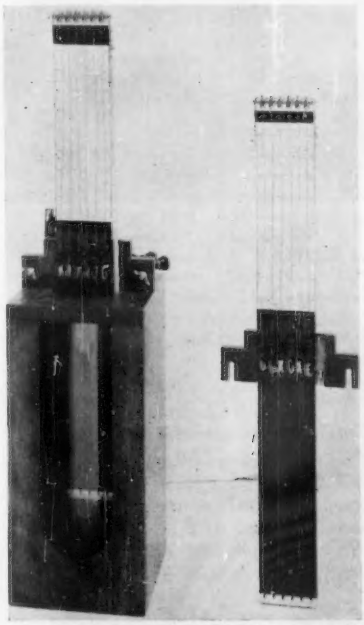


Fig. 7.—Diagram of shear creep and recovery apparatus.



Courtesy American Instrument Co.

Fig. 8.—Temperature-retraction apparatus.

[3] Manufactured by Firestone Tire and Rubber Co.

[3] ASTM Tentative Method of Test for Evaluating Low-Temperature Characteristics of Rubber and Rubber-Like Materials by a Temperature Retraction Procedure (TR Test) (D 1329), 1958 Book of ASTM Standards, Part 9, p. 1427.

steel scale to measure retraction or extension under temperature and load changes. The glass flask used as a bath acted as a magnifying glass to aid in reading the 1-in. bench marks inscribed on the specimen. No difficulties were noted in reading. Sufficient load was applied to extend the T-50 specimens 50 per cent as noted by the upper graduated scale. Component weights of clamp wire and string were counterbalanced but not the specimen weight. Although the pulleys were not immersed in the bath, some frictional forces were present. They should, however, be nearly the same for creep as for recovery measurements. The stress load was noted but did not enter into the calculations since strain was the important variable concerned. The procedures were as follows:

Tensile Creep:

1. Determine load to extend specimen 50 per cent at room temperature.
2. With load applied to specimen, flex 8 times ±10 per cent, then rest 10 min under load. Place in bath and measure at room temperature.
3. With load still applied, reduce temperature to +20 F, hold 10 min and measure.
4. Continue to 0 F, −20 F, −40 F, −60 F, and −80 F, hold 10 min and measure at each temperature.
5. At end of −80 F test release load and remove from bath. Observations obtained represent the equilibrium strain at the respective temperatures.
6. Place specimen in oven 10 min at 158 F.
7. Place specimen in bath without load, depress temperature to −80 F, hold 10 min at stabilized temperature.
8. Add same load as in step 1 and measure extension at 0.2, 0.5, 1, 2, 3, and 5 min.
9. Remove load, raise temperature to next step, hold 10 min, repeat steps 8 and 9 until back to room temperature.

Tensile Recovery:

Run same tests as in steps 1 through 6. After oven aging continue as follows:

1. With load applied cool specimen in bath to −80 F; hold for 10 min.
2. Remove load, measure bench marks at 0.2, 0.5, 1, 2, 3, and 5 min.
3. Add load, raise temperature to next step, hold 10 min.
4. Repeat steps 2 and 3 for each test temperature until back to room temperature.

Summary curves are shown in Figs. 9, 10, and 11.

Torsional Creep and Recovery

A Clash-Berg torsional tester (7) was used to determine both torsional creep and torsional recovery.[4] Rectahedral specimens, 2 in. long by ½ in. wide by a nominal slab thickness of 0.075 in. were placed individually in the 1-in. span between the jaws of this instrument, and the angular deflection was determined on the torsion head under a constant load and after removing the load, for the creep and recovery tests, respectively. The creep and recovery specimens were twisted through an angle obtained by suspending 5- or 15-g loads from each end of the load cord of the Clash-Berg apparatus for the Hevea and SBR specimens, respectively. These loads resulted in deflection angles ranging between 200 and 275 deg at 74 F.

All tests were performed with the specimens immersed in an ethyl alcohol bath contained in a Dewar flask. Temperatures were controlled and maintained within ±2 F by the alternate addition of solid carbon dioxide to cool the bath, and the insertion of a heat resistant glass test tube containing hot water, for the heating cycle. Temperatures were determined with a type-K potentiometer using a copper-constantan thermocouple inserted in a thin, sealed glass tube immersed in the liquid bath.

In the torsional recovery tests, a constant load was first applied to both

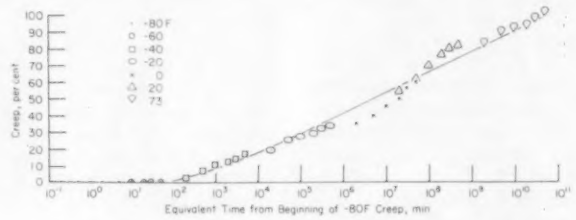


Fig. 9.—Time-temperature relationship from tensile creep of SBR compound.

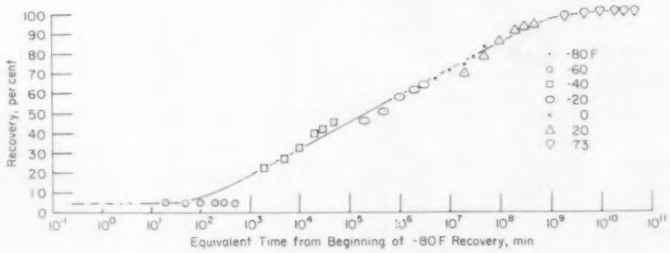


Fig. 10.—Time-temperature relationship from tensile recovery of SBR compound.

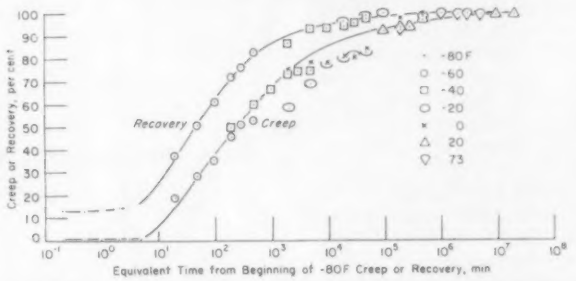


Fig. 11.—Time-temperature relationship from tensile creep and recovery of Hevea compound.

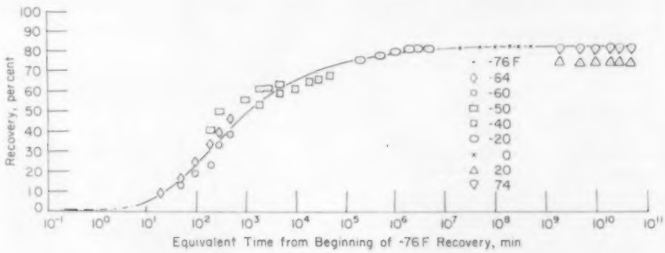


Fig. 12.—Time-temperature relationship from torsional recovery of Hevea compound.

[4] ASTM Method of Test for Stiffness Properties of Nonrigid Plastics as a Function of Temperature by Means of a Torsional Test (D 1043), 1958 Book of ASTM Standards, Part 9, p. 305.

ends of the load cord at 74 F and the specimen flexed 10 times through 20 deg of arc on either side of the apparent rest point. The test temperature was then reduced to the lowest experimental temperature, −76 F. After 10 min, the load was removed from both ends of the load cord and deflection angles were determined instantaneously, and after recovery times of 0.2, 0.5, 1, 2, 3, and maximum angle of twist at each temperature.

Stress Decay

A tensile stress relaxation apparatus (8) was used to determine the stress relaxation properties of the two experimental elastomer stocks in tension. The instrument and operational procedure have been described by Hanok *et al* (9). A photograph of the apparatus is given in Fig. 14 and of the specimen elongation jig in Fig. 15. Essentially the instrument consists of a jig, which provides a means for maintaining a strain constant to within 0.1 per cent of the extended specimen length during measurements, and a load-measuring device which in this case was a Hunter Force Indicator. Two of these indicators were used according to the magnitude of the measured stress, one having a 500-g capacity and the other a 5000-g capacity. The jig has fixed guides for extension in increments of 1 in. each. T-50 specimens,[5] measuring 2 in. between tab ends by 0.075 in. wide in the constricted portion by a nominal 0.075-in. slab thickness, were used in the stress relaxation tests. They were given a 50 per cent deflection; that is, they were extended from 2 in. to 3 in.

Figures 16 and 17 show per cent stress relaxation plotted against log time for Hevea and SBR compounds, respectively.

Figures 18 and 19 summarize the above data in a continuous curve of per cent stress *versus* log time.

A summary of the test results conducted by the three participating laboratories is shown in the following figures:

Shear, Recovery.....Figs. 3 and 4
Tensile, Creep and Recovery.....
Figs. 9, 10, and 11
Torsion, Creep and Recovery.....
Figs. 1, 2, 5, 6, 12, and 13
Tensile, Stress Relaxation.....
Figs. 16, 17, 18, and 19

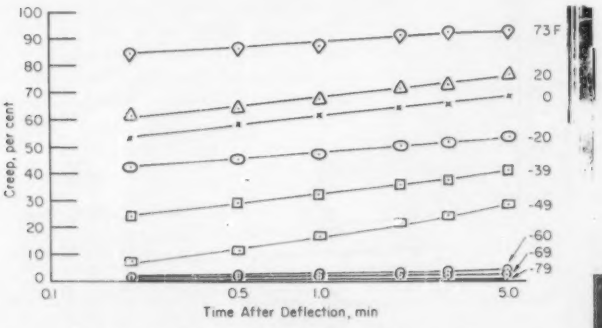


Fig. 13.—Torsional creep of SBR compound.

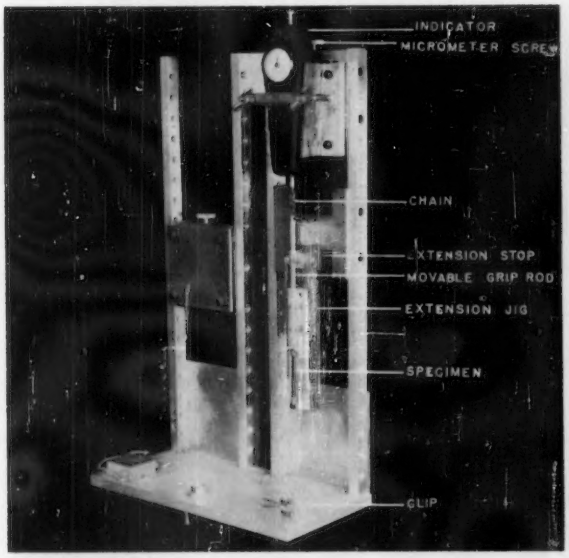


Fig. 14.—Tensile stress decay apparatus.

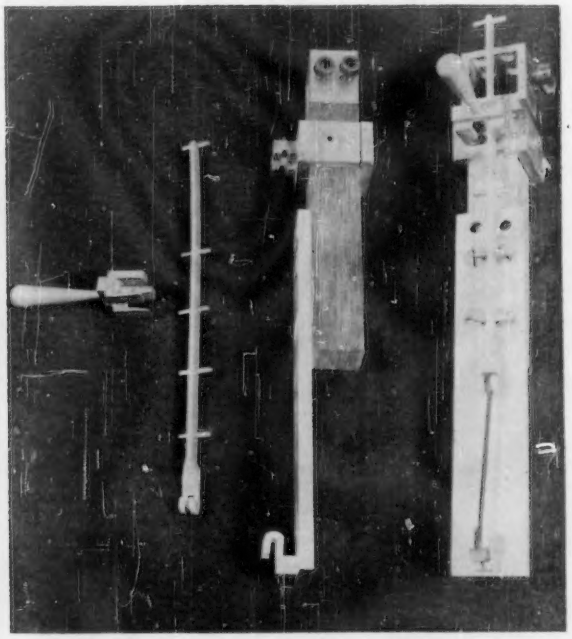


Fig. 15.—Specimen elongation jig—disassembled and assembled with specimen under strain.

5 min. The torque load was then reapplied and the temperature was raised 10 F. This procedure was repeated at the succeeding experimental temperatures of −70, −60, −50, −40, −20, 0, and 74 F.

The experimental results are summarized in Figs. 1, 2, 5, 6, 12, and 13. The curves were obtained by calculating the per cent creep as ratios of the creep (deflection angle) to the equilibrium values at equivalent temperatures, multiplied by 100. The recovery values were calculated as percentages of the

[5] ASTM Method of Test for Physical State of Cure of Vulcanized Rubber (T-50 Test) (D 599), 1958 Book of ASTM Standards, Part 9, p. 1289.

Analysis

Since the shear stress procedure has undergone the most thorough study and validation, the other procedures were examined for their comparable ability to furnish the same information.

It is evident from the data in Figs. 9, 10, and 11 that tensile creep from zero deformation did not follow the same deformation *versus* time path as did tensile recovery from equilibrium deformation. The reason for this lack of coincidence may be due to some inaccuracy in the test method.

Consider the characteristic modulus *versus* temperature curve for polymers shown in Fig. 20. The experimenta

sigmoidal curves in Figs. 6 and 12 show that the regions of glassy, leathery, and rubbery viscoelastic behavior were included in the experiments. The curves appear as inverse functions of the modulus of Fig. 20. The stress relaxation curve in Fig. 18 shows a similar resemblance to the characteristic modulus-temperature curve, but with the glassy region of the curve missing. The measurements were made only down to −60 F which appears to be the beginning of the glassy transition region.

The continuous curves shown representing time-temperature relationships can be represented by empirical equations of forms differing from those in (5). For example, the curve in Fig. 13 is expressed by the following equation:

$$Y = AB^{C \log t}$$

where:
Y = per cent creep or recovery,
t = time, and
A, B, and C are arbitrary constants.

In this case $A = 99.13$, $B = 0.002324$, $C = 0.4687$.

The methods and instruments for the torsional creep and recovery and for the tensile stress relaxation determinations all showed deficiencies of varying degrees. One of the less significant types of deficiencies was a direct result of the normal stiffening of the elastomer specimens at the lower experimental temperatures. This produced errors in the assumed return of the specimens, especially the SBR specimens, to zero deflection after removing the deflecting load during the torsional creep tests. The elastomer stiffening also prevented the manual extension of the specimens to the required 50 per cent for the tensile stress relaxation tests at temperatures below −60 F and −50 F for Hevea and SBR, respectively. Another deficiency was a consequence of the time-consuming manipulations involved in using the tensile stress relaxation apparatus, which caused some difficulty in determining the 0.2- and 0.5-min readings of stress. The significance of this defect was minimized by the method of calculating per cent stress as a function of the equilibrium stress.

Much more significant deficiencies in the torsional recovery method, using the Clash-Berg apparatus, involved mechanical difficulties in achieving the required simultaneous removal of the load from both ends of the load cord at the beginning of each 5-min recovery period. This caused inaccuracies in determining the exact time of load removal, the entanglement of the load cord, an imbalance in the torsion head, and a disturbance in the equilib-

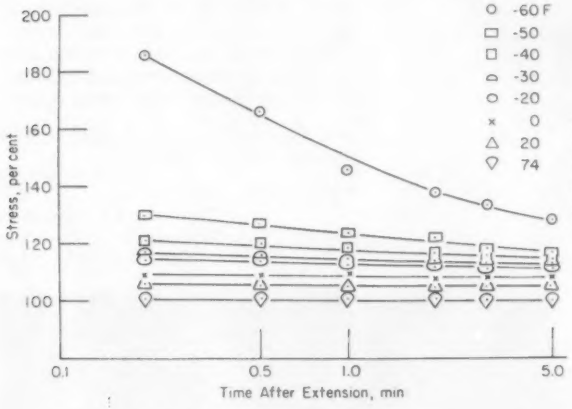


Fig. 16.—Tensile stress relaxation of Hevea compound.

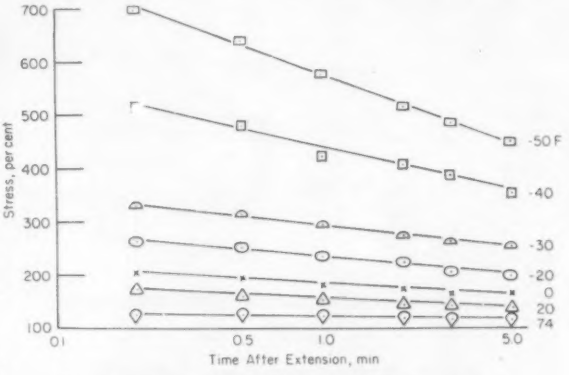


Fig. 17.—Tensile stress relaxation of SBR compound.

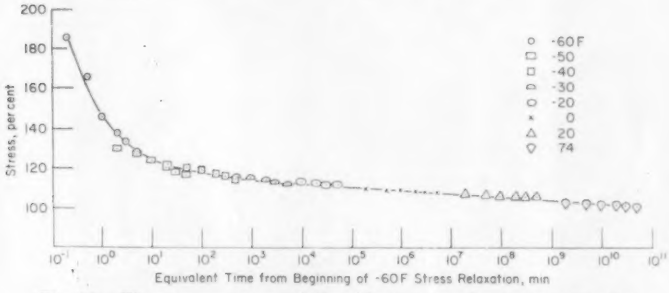


Fig. 18.—Time-temperature relationship from tensile stress relaxation of Hevea compound.

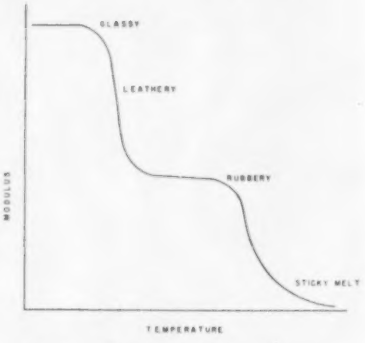


Fig. 20.—Characteristic temperature-modulus curve for polymers.

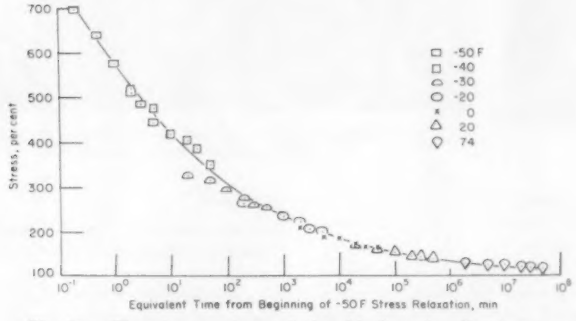


Fig. 19.—Time-temperature relationship from tensile stress relaxation of SBR compound.

brium position of the specimen. The significance of these deficiencies, reflected in the data of Fig. 12 was sufficient to warrant discontinuation of the test and to conclude that the Clash-Berg torsional stiffness apparatus is not suitable for the determination of torsional recovery of elastomers by the method described herein.

The incidence of values above 100 per cent in Fig. 6 may be attributed to variable frictional effects in the torsion head of the Clash-Berg apparatus. The scatter of the data in Fig. 12 may be due to disturbances in the equilibrium positions of the specimens during operation.

Discussion

The Conant type of plot which uses log time as abscissa is one way of summarizing the interaction between creep or relaxation, temperature, and time. For instance, it can be seen from Fig. 4 that SBR at −60 F takes about 10^8 min (70,000 days, 191.78 yr) to attain 90 per cent of its equilibrium creep or recovery. Of more practical interest to rubber technologists is the relative behavior at shorter time intervals, such as 0.6 to 60 sec. The concept described supplies a means of arriving at such quantitative values by extrapolating the creep or recovery values obtained to shorter time intercepts.

Figure 21 shows torsional creep of Hevea and SBR at −20 F. Extrapolation of these curves to the intercepts of 0.1 min (6 sec) and 0.01 min (0.6 sec) gives values reflecting degree of creep (or recovery) at these short intervals. From such extrapolated values can be constructed a set of curves such as Figs. 22 and 23 in which creep (or recovery) can be estimated directly against temperature for the three (or as many as are significant) orders of time.

The validity of such extrapolation may well be questioned. Neglecting for the moment errors inherent in the mechanism used (frictional effects, exactness of readings), the 1-min value is an observed value, the 0.1-min (6 sec) is extrapolated from the first actual reading (12 sec). The most questionable value is that for 0.01 min (0.6 sec). Observed plots of log time *versus* creep (or recovery) are usually straight lines (Fig. 21), within the time region in which readings are taken. Some of the single curves, however, will be concave upward and some concave downward depending on their position within the composite curve. Their extrapolation through a complete decade of time (from 0.1 min to 0.01 min) is a matter of judgment. Refinements in apparatus and procedures may throw additional light on the practicability of such extrapolations.

The authors know of no laboratory method to prove whether or not the values derived by this extrapolation are valid or accurate, and the idea is presented only as a basis for further experimental work. It might serve as a fingerprint method of characterizing the low-temperature response of elastomers, similar in a way to hardenability curves of ferrous alloys.

Roth (11) describes hardness measurements at a series of low temperatures on a Wallace meter. He obtained composite creep curves by matching segments of compliance *versus* log time curves, obtained at different temperatures. The data were normalized to correct for Joule effect by multiplying compliance by absolute temperature rather than by obtaining percentages of equilibrium deflection as was done in the present work. His method of analysis also permits long-time creep properties to be evaluated from relatively short-time tests and indicates that deflection of a rubber-like material under load is a unique function of time and temperature.

Payne(12)has shown how curve-fitting of the nature used in the present work can be used to obtain a T_s value which characterizes a particular polymer not only for various types of deformation but also for dielectric measurements. His T_s is a reference temperature to

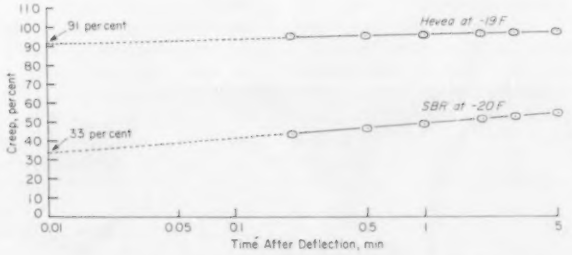


Fig. 21.—Torsional creep of Hevea and SBR compounds extrapolated to near-instantaneous response.

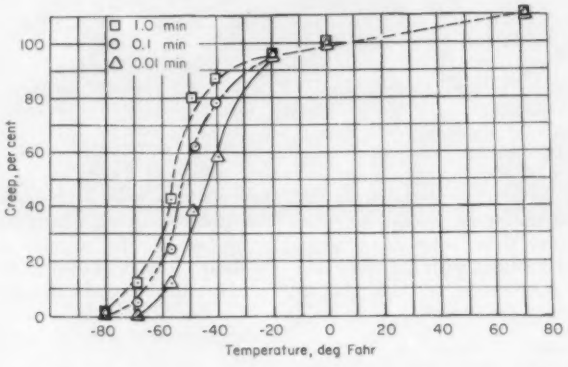


Fig. 22.—Summary of torsional creep *versus* temperature for Hevea compound.

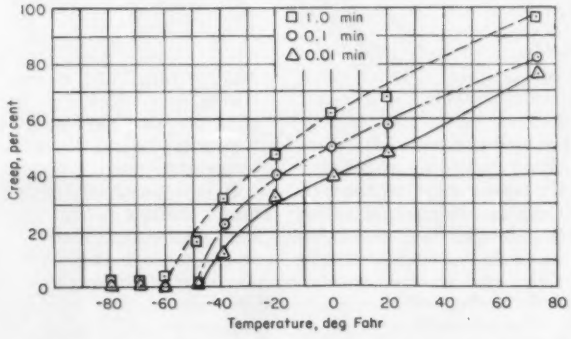


Fig. 23.—Summary of torsional creep *versus* temperature for SBR compound.

which all of the experimental data are reduced in plotting continuous curves.

The possibility of using resistance to indentation, which is a form of compressive loading, for developing a basic pattern of rheological response is indicated by the time-indentation curves (Figs. 5,6,7, of Labbe's summary of hardness tests(2). Eight different hardness testers were compared, and their response, in depth of indentation (or scale reading), is shown for time up to 100 sec).

Bearing in mind that the instruments differed in the mechanism of load application (spring *versus* dead weight) and that the unit stress at the indentation point varied in the instruments, the general pattern of response was similar to the observed creep behavior in shear, tension, and torsion, namely,

1. A region of almost instantaneous elastic response and high indentation around room temperature.

2. A region of slow response, within the 100-sec time—for example, −40 to −60 F for natural rubber gum stock.

3. A region of extremely slow response (−80 F or lower) where equilibrium indentation would be attained in a matter of hours or days.

Since Labbe was concerned only with hardness effects, no attempt was made to observe the rate of recovery after removal of major load. It is possible that these rates of recovery would be consistent with the creep and recovery phenomena as observed in shear, tension, and torsion.

Conclusions

The curves in Figs. 3, 4, 5, 6, 9, 10, 11, 12, 18, and 19 show the existence of continuous relationships between time, temperature, and the rheological properties of shear creep, shear recovery, torsional creep, torsional recovery, and tensile stress relaxation. There is excellent agreement between the torsional creep and recovery curves and the shear creep and recovery curves, and there is a significant resemblance between these and the tensile creep and recovery curves in Figs. 9, 10, and 11. The characteristic sigmoid-shape curve for Hevea is especially noticeable for the torsional, shear, and tensile methods. It is noteworthy that an inflection point appears over the narrow range of 42 ± 2 per cent creep in all of the creep curves for Hevea; and that the region of greatest rate of change of the creep occurs over two logarithmic time cycles. The inflection point occurs at a temperature of approximately −60 F. This appears to indicate a time-temperature-creep point above which the crude rubber behaves as an elastomer and below which it behaves as a nonserviceable, highly viscous material. Bennett *et al* (10) have noted that the lower limits of serviceability of elastomers are actually about 15 to 30 degrees above their glass transition temperatures. The glass transition temperature of natural rubber was placed at −97.6 F.

The relationship between stress relaxation and creep or recovery is not clearly demonstrated by the experimental curves. It should be noted that the stress relaxation data, Figs. 18 and 19, were not determined over the full range of temperatures covered by the creep and recovery curves. It appears from the continuous nature of the curves, however, that both the creep-recovery curves and the stress relaxation curves may be used as independent indices of elastomeric behavior.

Despite the scatter of the data for torsional recovery, Figs. 6 and 12 show an equivalence between torsional creep from zero deformation and torsional recovery from equilibrium deformation, which is similar to the equivalence between shear creep and shear recovery (5). The tensile method does not demonstrate this equivalence.

Recommendations

Since the pattern of rheological response of elastomers at low temperatures appears to be essentially the same regardless of the manner of stressing (shear, tension, torsion), it would be reasonable to expect the same response in compression, and some work in this direction has been described by Roth (11).

Compression (or indentation) testing has recently undergone considerable refinement, and instruments are available (Wallace, Material Laboratory Indentometer, Pusey & Jones (2)) which embody improvements to minimize frictional and thermal expansion effects, and which will measure with great precision the changes in indentation with various loads over a wide temperature range.

It is recommended that a study be made, utilizing indentation at various loads (major and minor) over the usual range of temperatures, to explore the possibility of simpler instrumentation to establish the basic curve of rheological response.

Acknowledgments:

The authors express their indebtedness to the management of their respective laboratories for cooperation in accomplishment of the painstaking task involved in collection of pertinent data.

Our thanks are also extended to Mr. R. S. Havenhill, of the St. Joseph Lead Co., ex-chairman of Subcommittee 27 of ASTM Committee E-1 on Methods of Testing, and his successor, Mr. Frank M. Gavan of Armstrong Cork Co., for their unflagging patience and encouragement without which the work could not have been brought to this conclusion.

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A Technique for Gripping High-Strength Fabrics During Physical Tests

By KARL F. PLITT and LEE A. DUNLAP

THE DETERMINATION of physical properties of high-strength fabrics, such as tensile strength and burst strength, are complicated by the tendency for yarns to slip during testing. A method is described here for laminating the gripped area of the fabric with Saran film to overcome this difficulty.

The fabric tested was 2 by 2 basket-weave nylon material with 20 double yarns per in. in the filling and 21 double yarns per in. in the warp. It weighed 13 oz per sq yd and had been scoured at 100 C and heat treated at 121 C.

The 2-mil thick Saran film used to impregnate the fabric was in the form of flat tubing about 8 in. wide. The other plastics films used were 1.5-mil thick polyethylene and uncoated cellophane.

The laminating technique was developed for a piercing test that is intended to simulate a condition that the fabric would encounter in use. The initial tests with nylon fabric were made according to a modification of the method described in Federal Specification CCC-T-191, Textile Test Methods, Method 5120. This consists of holding the specimen in a ring clamp of 1.750 ± 0.001 in. internal diameter and bursting the fabric with a spherical plunger at a crosshead speed of 12 ± 0.5 in. per min. These tests were made with a steel plunger with a hemispherical end of ½-in. diameter instead of the steel ball used in Federal Method 5120.

The results of these tests were erratic. Yarns pulled from the edges of the specimens, and in some cases the yarns were not broken but had slipped aside to permit passage of the plunger. It was evident that poor gripping of the fabric was responsible for the erratic results.

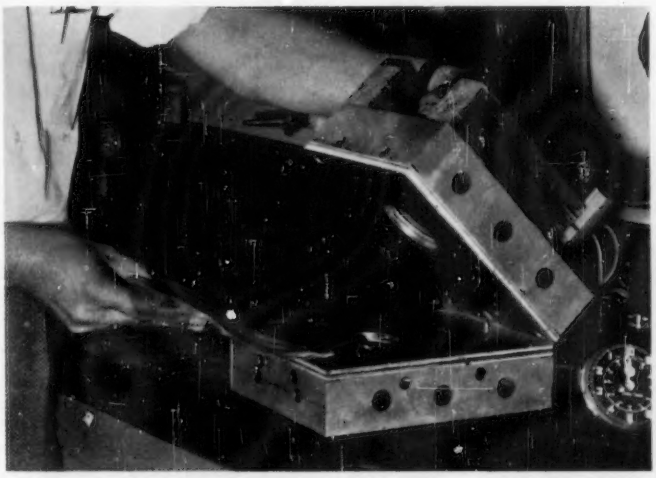

Fig. 1.—Laminating press.

Various methods of gripping the specimens were investigated. The use of such gripping materials as rubber, sandpaper, and leather reduced the slippage but did not eliminate it. Attempts were made to reduce yarn slippage by coating the edges of the specimens with various adhesives and coatings. Adhesives had been used by Schiefer[1] as a technique in gripping textile fibers. Difficulty was encountered with adhesives and coatings in maintaining a uniform test area free of the bonding material. Stone[2] had developed a technique for gripping the ends of cordage fibers during tensile tests by laminating the fiber tips. This technique was successfully modified for holding nylon specimens during the piercing tests.

A laminating press, Fig. 1, was built to laminate the edges of the specimen without heating the central test area. This press was made of two similar 7

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[1] H. F. Schiefer, W. D. Appel, J. F. Krasny, and G. G. Richey, "Impact Properties of Yarns Made from Different Fibers," *Textile Research Journal*, Vol. XXIII, No. 7, July 1953.

[2] W. K. Stone, Textiles Section, Nat. Bureau of Standards, private communication.

by 9 by 2 in. sheet-metal boxes in which heaters were mounted. The heaters were doughnut-shaped 330-w heaters as used in heavy-duty electric hot plates. Temperatures of both top and bottom heaters were controlled by a gas-filled-bulb thermoregulator mounted with its bulb against the back surface of the top platen. The platens of the press were smooth, $\frac{3}{8}$-in. thick aluminum-alloy plates. These heavy plates were necessary to heat the specimen evenly. A $2\frac{1}{4}$-in. diam hole was cut in each platen and numerous smaller holes in the sides of the sheet metal boxes to provide ventilation to the central test area of the specimen during lamination. Temperature measurements with a fine chromel-alumel thermocouple showed a temperature of 92 C in the center of the open test area while the platen temperature was 175 C. A small light was mounted under the hole in the bottom press section to facilitate centering the specimen. A weight produced a pressure of about 2 psi on the specimen.

The optimum time and temperature for lamination were determined. Nylon fabric specimens were sandwiched between pieces of plastic film. Cellophane film was placed on either side of the assembly during lamination to prevent adhesion to the press platens. The temperature was measured by a fine chromel-alumel thermocouple inserted in the assembly between the cellophane and other plastics layers. Specimens were laminated at platen temperatures of 175, 190, and 200 C for 3, 4, and 5 min. Specimens laminated at 200 C for either 4 or 5 min performed equally well in the piercing test. A few specimens prepared at 210 C became badly discolored and were somewhat brittle after heating for 4 min.

TABLE I.—EFFECTS OF COATING AND MOISTURE ON PIERCING STRENGTH OF NYLON FABRIC.

Coating on Fabric, per cent[a]	Moisture Condition of Fabric: 0 per cent Relative Humidity — Piercing Strength, lb[b]	0 per cent Relative Humidity — Coefficient of Variation, per cent	50 per cent Relative Humidity — Piercing Strength, lb	50 per cent Relative Humidity — Coefficient of Variation, per cent	93 per cent Relative Humidity — Piercing Strength, lb	93 per cent Relative Humidity — Coefficient of Variation, per cent	Wet — Piercing Strength, lb	Wet — Coefficient of Variation, per cent
None...	705	6.7	721	4.7	708	5.6	649	5.7
1.3....	744	5.0	771	1.6	750	2.8	663	3.1
4.5....	747	7.0	778	2.1	677	7.6	651	5.6
11.4....	796	3.1	810	2.3	764	4.9	680	3.4

[a] The coating was composed of: polyamide resin 94 from General Mills, Inc., 800 g; rosin, 100 g; hydroabietyl alcohol, 50 g; tricresyl phosphate, 30 ml; and isopropanol-toluene (30 to 70) to make 4 liters. It was applied by dipping and passing the fabric through squeeze rolls. Applied full-strength, the solution produced an 11.4 per cent coating based on the weight of the original fabric conditioned at 23 C and 50 per cent relative humidity. The mixture was diluted 1:4 with the isopropanol-toluene solvent to produce the 4.5 per cent coating and 1:9 to produce the 1.3 per cent coating.

[b] Each value is the average of 12 test results.

Nylon laminates were made with 1.5-mil polyethylene and 2-mil Saran films. Tests with 20 specimens of each type of laminate gave piercing strengths of 549 lb for the nylon-polyethylene laminates and 655 lb for nylon-Saran laminates, with coefficients of variation of 5.3 per cent and 5.0 per cent, respectively. No slippage was observed in any of the specimens. Since the strengths obtained with Saran laminates were consistently higher and had a lower coefficient of variation than those obtained with polyethylene laminates, the Saran was considered the more desirable laminating material. Tests with several types of Saran film showed no significant differences in test data. A Saran film that does not shrink appreciably during lamination is easier to use than a high-shrinking type. Saran flat tubing is a convenient material to use in this application.

Figures 2 and 3 show laminated and unlaminated specimens after the piercing test. The pulled and unbroken yarns visible in Fig. 2 are not present in the laminated specimen in Fig. 3.

Typical Test Results

A series of tests was made with Saran-laminated specimens to determine the effectiveness of this test procedure under a variety of moisture conditions with both uncoated and coated nylon fabrics. The coating material used was a polyamide resin formulation expected to increase friction between yarns and to reduce yarn slippage. It was applied in three different amounts. The specimens were coated, and conditioned according to a statistical design to randomize the specimens.

After coating and laminating, the specimens were conditioned at four different moisture conditions. The first group of specimens was dried over phosphorus pentoxide; the second group was conditioned at 50 ± 4 per cent relative humidity; and the third group was

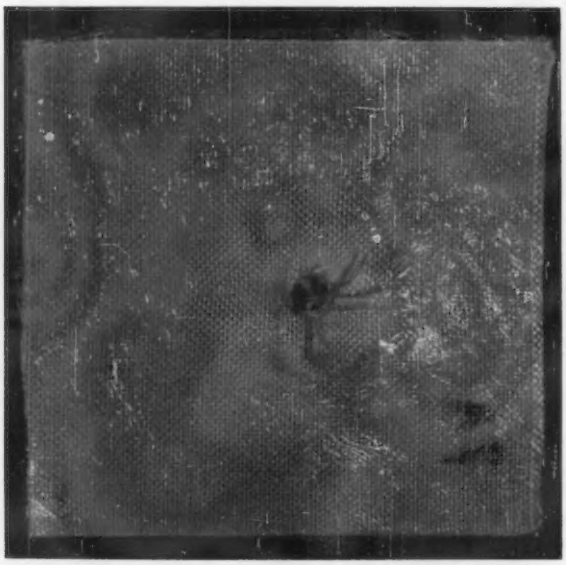

Fig. 2.—Laminated fabric specimen after piercing test.

Fig. 3.—Unlaminated fabric specimen after piercing test.

conditioned at 93 per cent relative humidity over a saturated solution of ammonium phosphate. These three groups of specimens were conditioned for seven days prior to testing. The fourth group of specimens was immersed in water 24 hr before testing.

Table I summarizes the results. The coefficients of variation are quite low, considering the nature of the test and the material tested. It is possible by means of this procedure to observe trends and small differences that would not be apparent with a less precise method. For example, Table I shows that the nylon fabric has maximum strength at 50 per cent relative humidity for any given amount of coating on the fabric. It is also apparent that the strength increases with increasing amounts of coating. The method is satisfactory with wet fabrics, as is evidenced by the low coefficient of variation of the wet-fabric test results. The authors believe this laminating technique may have application in preparing specimens of high-strength fabrics for other physical tests.

Recommended Laminated Procedure

The nylon cloth is cut into 5½-in. squares, which are placed in flat Saran tubing in which a 2-in.-diam hole has been cut. (Holes may be cut in as many as 25 pieces of tubing at one time by means of a sheet-metal punch.) The tubing is covered with sheets of cellophane to prevent sticking to the platens.

The laminate assembly is centered in the press, which has been preheated to 200 C. The assembly is laminated for 4 min at 2 psi and 200 C.

An Improved Method for the Determination of the Normal Consistency of Gypsum Plasters

By R. A. KUNTZE

A modification of ASTM Method for the Determination of the Normal Consistency of Plasters (C 26 – 56)[1] which employs a conical instead of a cylindrical plunger is described. With this apparatus a linear relationship exists over a wide range between the depth of penetration of the conical plunger and the water to calcined gypsum ratio of the plaster, so that the normal consistency can be estimated from a single test.

Experiments with cones of different apex angles and weights and with different calcined gypsums are discussed. The results indicate that the slope constant is dependent on the apex angle of the cone and is independent of the type of calcined gypsum. The method appears to be an improvement over others, for which simple relationships are absent.

THE NORMAL consistency of a plaster can be defined as the water to calcined gypsum ratio at which a suitable workability is obtained. The determination of this ratio is important, since a number of properties of the plaster, such as strength and setting time, are related to it (**1**).[2] However, these determinations have always presented difficulties because of the apparent thixotropic properties of the plaster. For this reason methods that involve a minimum of shear or flow by measuring the resistance of the plaster to penetration, or to spreading under its own weight, are usually employed in practice.

Several test procedures have been developed in connection with standards which attempt to provide a reproducible method of measuring some arbitrary quantity defined as normal consistency.[3] In most cases, an attempt has also been made to achieve simplicity. The ASTM method, using a specified penetration depth of a cylindrical plunger as a standard measure for the normal consistency, appears to be the most widely accepted. However, there is no simple relationship between the depth of penetration of the cylinder and the consistency of a plaster (**2,3**). Consequently, it is not possible to predict the amount of water required for the normal consistency from a penetration other than the specified one. Several repetitions of the entire testing procedure are usually required until a plaster with the correct penetration, that is normal consistency, is obtained. Since this is time consuming, other methods are often preferred in practice (**4**). The stepwise addition of water to the plaster, for example, in cases where low penetrations are obtained initially, is not advisable as a method of shortening the determination. Different results are obtained in this manner than when mixing is carried out in one step and the effect is probably related to the thixotropic behavior of gypsum plasters.

With the cone consistometer described in the present paper it has been found possible to determine the normal consistency of a plaster by a single test. The method is based on the fact that a linear relationship exists between the penetration depth of a conical plunger and the water to calcined gypsum ratio of a plaster. By using a calibration factor, the normal consistency of a plaster can thereby be calculated from a single penetration value. Since repetitive tests are obviated, the method represents a considerable saving of time and is particularly useful when only small samples are available. It is also possible to determine the magnitude of changes in the normal consistency of a plaster during aging, or caused by additives, in a fast and accurate manner.

A number of experiments have been carried out with cones of different apex angles and weights in order to select the most suitable one for a standard testing method.

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[1] ASTM Methods of Testing Gypsum and Gypsum Products, 1958 Book of ASTM Standards, Part 4, p. 297.

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

[3] German Standard, DIN 1164; Soviet Russian Standard, O.C.T. 2645; British Standard, BS 1181/1941; Australian Standard, Interim Spec. 317.

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Test Method and Apparatus

In the present method the procedure for determining the normal consistency of a plaster is similar to the test described in ASTM Method C 26 – 56. To obtain more reproducible mixing conditions hand mixing was replaced

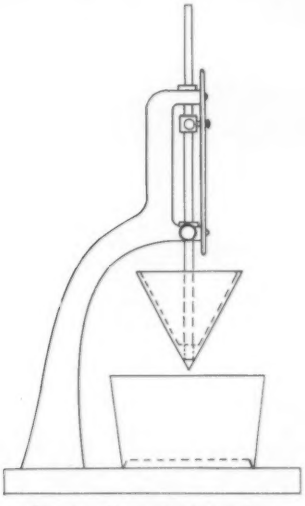

Fig. 1.—Cone consistometer.

by a mechanical mixer,[4] with the beater modified slightly to resemble that used for mixing hydraulic cement mortars (ASTM Method C 305 – 58 T).[5]

For the actual penetration test the usual ASTM instrument, the modified Vicat apparatus, was used. The cylindrical plunger was replaced by cones of apex angles of 45 deg, 53 deg 08 min, and 60 deg. The cones were hollow and made from aluminum with a stainless steel tip for protection. Each cone had a total height of 45 mm, the maximum diameter corresponding to the respective apex angle (Fig. 1).

Instead of the usual conical ring, disposable 4-oz waxed paper cups were used (height 42 mm, top diameter 73 mm, bottom diameter 61 mm).[6] Paper cups of this type have been used in consistency and setting time determinations for some time in these laboratories and elsewhere and have been found satisfactory. No other changes of the testing procedure were made.

A simplified cone was also designed for plant use (Fig. 2). It consists essentially of a cone with a millimeter scale engraved in its surface, and a short handle. When the center of gravity is near the tip of the cone it is possible to make penetration tests without the aid of a stand or bracket, using any suitable vessel to contain the plaster.

[4] Hobart Model 3-CC.

[5] ASTM Method for Mechanical Mixing of Hydraulic Cement Mortars of Plastic Consistency, 1958 Book of ASTM Standards, Part 4, p. 171.

[6] Continental Can No. 4, Mono Paper containers, 4-oz, waxed, flare top.

Results and Discussion

For preliminary experiments, cones with apex angles from 45 to 60 deg and weights from 30 to 50 g were selected. At an apex angle of less than 45 deg, the total weight of the cone and rod must be less than 30 g in order to obtain the same penetration depth as the Vicat plunger at normal consistency. This presents some difficulties in that plastic materials must be used in construction of the cone or the wall thickness must be reduced, resulting in an instrument which is less robust. In addition,

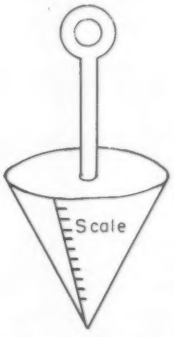

Fig. 2.—Simplified cone consistometer.

poorer reproducibility is noticeable at low weights, probably due to frictional effect between rod and holder. Cones with an apex angle larger than 60 deg have a top diameter close to or larger than that of the sample container. This fact does not permit deep penetrations except with wider containers, which necessitates the use of larger samples. Also, the slope constants obtained with these cones are relatively small, with a consequent reduction in accuracy. The effect of apex angles on the relationship between penetration depth and the water to calcined gypsum ratio for a typical plaster is illustrated in Fig. 3. It is apparent that the relationship is linear over a wide range of water to calcined gypsum ratios. The slope constants are recorded in Table I, together with those obtained from experiments in which the weight of the cone was also varied. The results show that the slope constant is dependent on the apex angle of the cone but is independent of the weight. As would be expected, the level of penetrations increases with the weight of the cone for any given apex angle.

Based on these findings, a cone with an apex angle of 53 deg 08 min, in which the penetration depth is equal to the diameter of the cone at the surface of the plaster, was selected for general testing. In order to obtain a penetration depth at normal consistency equal to that of the Vicat plunger, the weight of the cone was adjusted to 35 g for unsanded plasters and to 50 g for 2:1 sanded plasters. Plots of penetration depth *versus* water to calcined gypsum ratio of unsanded and sanded (2:1) plasters are given in Figs. 4 and 5 and the corresponding slope constants are reported in Table II. These values were obtained with four commercial calcined gypsums prepared from gypsum rocks of different origin. The results show that for a cone of a given

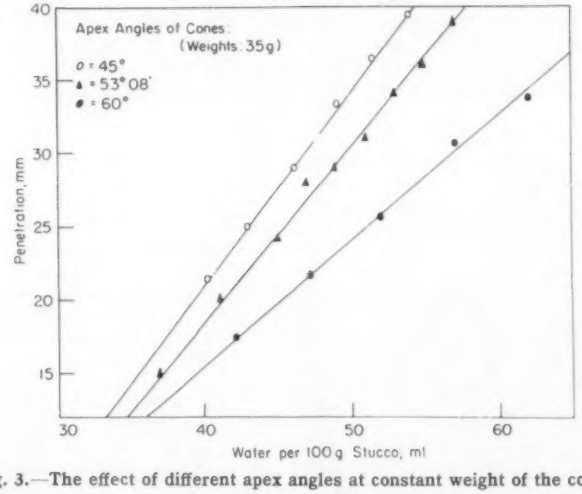

Fig. 3.—The effect of different apex angles at constant weight of the cone.

TABLE I.—EFFECT OF APEX ANGLE AND WEIGHT OF THE CONE USING CALCINED GYPSUM TYPE B.

Apex Angle	Weight, g	Slope Constant[a]	Penetration at Normal Consistency, mm[b]
45 deg	30	1.37	31.0
45 deg	35	1.35	34.0
45 deg	40	1.30	37.5
53 deg 08 min	30	1.15	27.5
53 deg 08 min	35	1.18	30.0
53 deg 08 min	40	1.19	32.5
60 deg	30	0.79	21.5
60 deg	35	0.81	23.5
60 deg	40	0.80	25.5

[a] Probable error of the slope constants <0.01.

[b] Accuracy of penetration reading 0.5 mm.

apex angle the slope constant is independent of the type of calcined gypsum. Also, with cones of these specifications, the respective penetrations are the same as those with the Vicat plunger at normal consistency for all the calcined gypsums, both sanded and unsanded. Thus the method should be of general applicability, the normal consistency of any plaster as defined by ASTM Method C 26 – 56 being obtained from a single penetration experiment using the 53 deg 08 min cone at the correct weight. However, it is possible that some plasters may have slope constants or penetrations at normal consistency different from those given in Table II. In principle it is advisable, therefore, to determine the particular slope constant for each new material. The single-step procedure outlined above can then be applied using the new calibration factor. Obviously an arbitrary value for normal consistency can be defined in terms of a given penetration of the cone.

During the large-scale examination of the effects of wetting and dispersing agents on the consistency of plaster using the cone consistometer, the reproducibility of the determinations was found to be 0.5 ml.

Further experiments indicated that the cone penetration method is limited to materials with consistencies similar to that of plasters. An attempt to apply this method to much stiffer portland cement pastes was not successful.

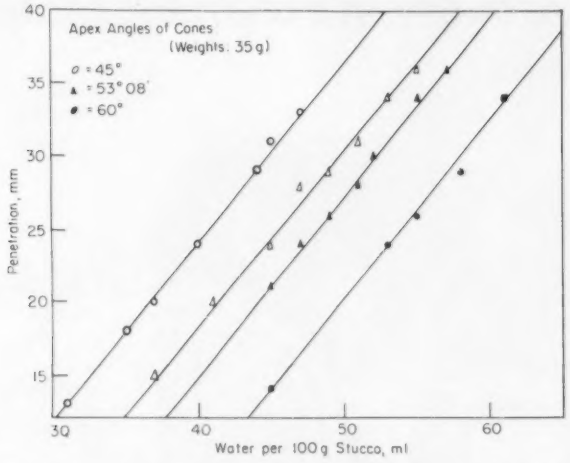

Fig. 4.—The effect of different calcined gypsums, unsanded (cone with an apex angle of 53 deg 08 min and a weight of 35 g).

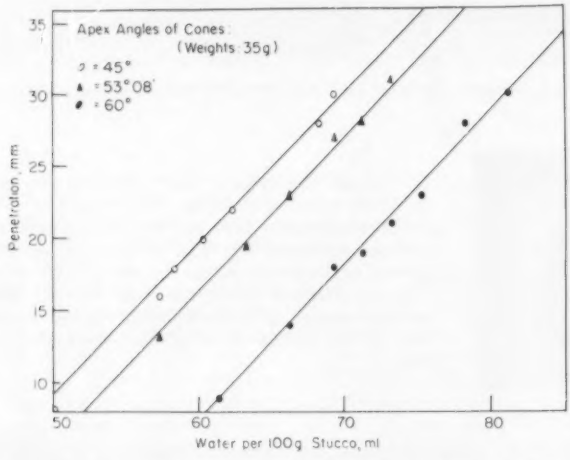

Fig. 5.—The effect of different calcined gypsums, 2:1 sanded (cone with an apex angle of 53 deg 08 min and a weight of 50 g).

Conclusions

1. The penetration of a conical plunger is directly proportional to the water to calcined gypsum ratio of sanded and unsanded plasters over a wide consistency range.

2. The slope constants of the relationship are dependent on the apex angle of the cone but not on its weight or the type of calcined gypsum.

3. The depth of penetration at the normal Vicat consistency varies with both the weight and angle of the cone.

4. A cone having an apex angle of 53 deg 08 min and a weight of 35 g for unsanded plasters and 50 g for sanded plasters has been found to be most suitable for standard consistency measurements. Once the relationship between penetration and the water to calcined gypsum ratio has been verified for a given type of calcined gypsum, the method permits the determination of the normal consistency of a sample from a single test.

TABLE II.—EFFECTS OF DIFFERENT CALCINED GYPSUMS[a]

Tye of Calcined Gypsum	Aggregate Condition	Slope Constant, mm per ml[b]
A.....	Not sanded	1.26
B.....	Not sanded	1.18
C.....	Not sanded	1.25
D.....	Not sanded	1.25
Average slope constant.....		1.23
A.....	2:1 sand-calcined gypsum ratio	1.07
B.....	2:1 sand-calcined gypsum ratio	1.10
C.....	2:1 sand-calcined gypsum ratio	1.12
Average slope constant.....		1.10

[a] Apex angle of cone 53 deg 08 min, weight of 35 g for unsanded and 50 g for sanded samples.
[b] Accuracy of penetration reading 0.5 mm. Probable error of the slope constants <0.01.

Acknowledgments:

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(2) W. Albrecht, "Steifemessungen an Gipsbrei und Gipsmörtel" ("Consistency Determinations on (Unsanded and Sanded) Gypsum Plaster"), *Zement Kalk Gips*, Vol. 8/44 (1955), No. 1, pp. 19–23.

(3) W. Albrecht, "Stuckgips und Putzgips" ("Gypsum Hardwall Plaster and Gypsum Finishing Plaster"), *Fortschritte und Forschung im Bauwesen*, Series D, No. 15 (1953).

(4) R. Hamilton, "How They Test Gypsum Cement and Plasters for the Ceramic Industry," *Ceramic Industry*, Vol. 61 (1958), No. 1, pp. 68–71, 95.

A Vicat-Type Penetration Tester for Evaluating Hardness and Elastic Recovery in Polymeric Materials

By K. W. GARDINER, T. F. JORDAN, and F. W. ADAMS

THE NEED for a simple instrument for evaluating the penetration hardness and elastic recovery of various polymeric materials has been recognized for some time. These properties are of great interest not only for characterizing materials, but also for measuring degree of cure and relating it to performance in use. "Shore hardness," the previously employed indicator, is at best inadequate for measuring penetration hardness, is limited to use with thick specimens, and does not indicate resiliency. To be most useful, the required instrument should be readily applicable to polymeric materials as encountered in typical commercial applications. For example, plastisols and other types of linings in crowns and caps, films, enamel coatings, and even sealing compounds applied in various ways, should all be handled with equal ease. In addition, the evaluating instrument must provide readings that are directly related to either penetration hardness and natural resiliency or the cure of the material being tested.

It was felt that the parameters that best describe hardness and elastic recovery would be the rate of penetration of a standard needle, as in the Vicat-type of test, and the degree of elastic recovery exhibited when the driving load is removed from the penetrating needle. With these in mind, an instrument and test procedure has been developed around the well-known Vicat penetration test,[1] which has been used for measuring the softening temperature of some plastics. The procedure has been used successfully to measure the penetration hardness and elastic recovery of a number of polymeric materials produced under a wide variety of conditions.

Description and Operation of the Instrument

The instrumentation shown in Fig. 1 uses the basic Vicat principle of needle penetration. Its major components are:

Fig. 1.—Instrument using the basic Vicat principle of needle penetration.

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F. W. Adams received S.B., S.M., and D.Sc. degrees in chemical engineering from M.I.T., where he continued on the faculty in the Chemical Engineering Department for 14 years. This work was largely on industrial research and development, in which fields he has continued during his professional life. For the past six years, he has been with the Continental Can Co., where he is now director of research—chemistry.

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[1] ASTM Method of Test for Vicat Softening Point of Plastics (Tentative) 1958 Book of ASTM Standards, Part 9, p. 406.

(*A*) the penetrating needle assembly, (*B*) a regulated power supply, and (*C*) a Varian 10-mv strip-chart recorder. A T-42 ionization transducer[2] is used to measure the needle motion. Linear motion of the penetrating needle is converted into a measurable electrical signal by the transducer system, which combines an oscillator and an ionization transducer for detecting the small variations in capacitance resulting from the penetrating needle's motion.

The needle penetrator assembly is shown in Fig. 2. In operation, the cylindrical Vicat-type needle (*A*), 0.04 in. in diameter (0.0013-sq in. face area), is actuated by the free-moving shaft (*B*) to which standard lead weights (*C*) totaling 750 g can be applied. At the maximum loading, including the weight of the shaft (105 g), the face loading of the needle is about 1450 psi—a value in the range of pressures used in several commercial applications of polymeric materials. The specimen under test is positioned on the vertically adjustable platform (*H*). The weights are added to or removed from the shaft (*B*) by a fork-type lift (*D*) mounted to the vertically adjustable shaft. The penetrating needle and actuating shaft can be locked into a suspended position prior to the test by the locking arrangement (*E*) located in the shaft's supporting bearing assembly. The motion of the shaft and penetrating needle is followed by the capacitor plate attached to the top of the shaft and located in the upper housing (*F*). The control knobs (*G*) provide a means for manually raising and lowering the specimen platform (*H*) and the fork lift (*D*).

In operation, the test specimen is positioned on the platform underneath the penetrating needle, which is locked in its uppermost position, The desired weight is added to the shaft and the recorder's scale of magnification of the needle's motion for the test is adjusted with the electronic controls located on the panel of the housing (*F*). The specimen is then raised by the supporting platform until the needle touches the surface of the specimens. An electrical contact in the supporting shaft (*B*) is closed by the needle as it just touches the test surface. When this contact closes, a red jewel is lighted on the upper housing (*F*), indicating that the needle is in starting position.

Having established the starting point and motion sensitivity of the needle, the test is started by simply releasing the lock (*E*) holding the weighted shaft (*B*). The added weights gradually force the penetrating needle into the specimen, and the resulting motion is translated into an electrical signal by the transducer. The transducer output is recorded on the Varian strip-chart recorder. After several minutes of penetrating motion, the weights (*C*) are carefully removed from the shaft and the elastic recovery of the test material is recorded by the needle's upward movement under just the weight of the shaft (105 g). Thus, the strip-chart recorder presents graphically both the downward penetration and the upward elastic-recovery motion of the needle. After a test is completed, the movable shaft (*B*) can be raised manually and locked in place while the test is replaced with another specimen.

The instrument adjustments available will permit the testing of specimens of varying thicknesses and shapes. The sensitivity adjustment of the transducer can provide a full-scale strip-chart reading for a needle motion as small as 0.7 mil or as large as 125 mils. Thus, assuming that one can read the strip chart to an accuracy of one tenth of full scale, a penetrating motion as small as 0.07 mil can be detected and recorded. This order of sensitivity would be required for measurements on very thin films, while the larger scale range—125 mils full scale is desirable for thicker and softer specimens where a fairly deep penetration would occur. Also, the depth of penetration can be controlled in part by reducing the driving weight on the needle from the maximum of 855 g, (added weights plus shaft) to a minimum value of approximately 105 g, which is the weight of just the needle and shaft assembly alone.

[2] Model 901-1 Decker Delta Unit, available from Decker Aviation Corp.

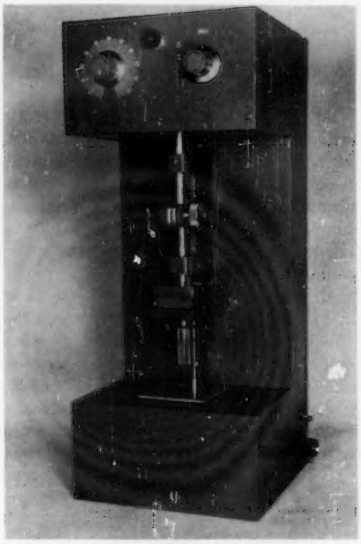

Fig. 2.—Needle penetrator assembly.

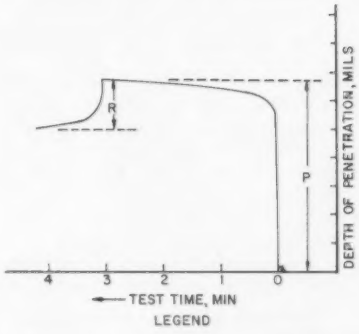

Fig. 3.—Recreated penetration curve.

P = depth of penetration of needle for a fixed load, mils

Per cent P = per cent penetration = $\frac{P}{\text{sample thickness}} \times 100$

R = recovery = needle motion when fixed load is removed, mils

Per cent R = per cent recovery = $\frac{R}{P} \times 100$

Discussion

Shown in Fig. 3 is a typical penetration and elastic-recovery curve recreated from an actual experimental plot obtained with a cured commercial polymeric specimen. This will serve as a model to show what measurements are made to describe penetration hardness and resiliency. As indicated, the plot runs from right to left with the test starting at 0 min. At the start, as the weighted needle is applied to the specimen, an initial rapid penetration occurs, as indicated by the vertical portion of the curve. The depth of penetration, P, achieved is a measure of the hardness or firmness of the material and will vary in magnitude with the material or with the degree of induced cure. The per cent penetration is most useful for comparing different specimens where thickness may be a variable.

After the initial penetration has reached equilibrium, the test is permitted to continue for several minutes, then the weights are removed. Elastic recovery of the material will push the needle back up as indicated by the dip, R, in the penetration curve. The

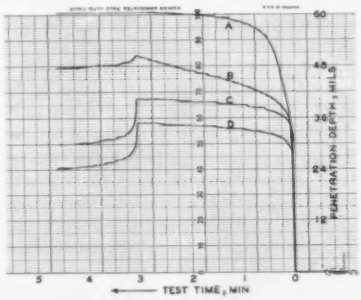

Fig. 4.—Strip-chart penetration records.

Load of 750 g applied. Test material is a commercial plastisol compound cured at the following conditions:

A—60 sec at 275 F
B—60 sec at 300 F
C—60 sec at 325 F
D—several minutes at 380 F

magnitude of R will, of course, also depend upon the nature of the material or the degree of cure. Again, the per cent recovery is a better figure for comparisons between specimens. In practice it is desirable to use all four values—P, per cent P, R, and per cent R—when applying the method. It has been found in those cases studied so far that P is a maximum and R a minimum for undercured specimens, with R increasing and P decreasing as the degree of cure increases.

Figure 4 shows actual experimental curves illustrating a practical application of the method to the evaluation of cure in a series of typical commercial polymeric materials. Curve A represents an uncured specimen baked at 275 F. As shown, a maximum penetration is achieved with no elastic recovery. As the temperature is raised to 300 F, the depth of penetration is less and there is some indication of elastic recovery, but the specimen is still undercured. Full cure is obtained at 325 F with a reduced depth of penetration and a measurable amount of elastic recovery. Heating to a higher temperature—380 F—produces only a harder cure as indicated by a further reduction in the amount of penetration with no gain in elastic recovery.

The method will not only detect the effect of temperature upon cure, but can also resolve the effect of time of cure at any given bake temperature. Experimentally, it has been possible to evaluate the difference achieved with a 15-sec variation in bake time at 325 F for a given composition.

Conclusion

Instrumentation has been developed which can measure the penetration hardness and resiliency of polymeric materials in terms of depth of penetration and extent of elastic recovery obtained with a Vicat-type penetration needle. The results obtained are reproducible and of adequate precision for specimen thicknesses from 125 mils down to 0.7 mils and can be obtained directly on commercial specimens of caps and crowns. The instrument has been successfully used in evaluating the progress and extent of cure of cap sealing compounds. Simplicity of operation makes the method ideal for quality control as well as for research.

Technical Note

A Reverse-Flow Viscometer

THE viscometer described here is a modification of the Cannon-Fenske reverse-flow viscometer (see Appendix B, ASTM Method D 445).[1] The modifications reduce the vertical alignment error and improve the filling procedure.

The construction of this viscometer is in most respects identical with the Cannon-Fenske reverse-flow type. In Fig. 1, it can be seen that the tubes L and C have been bent to allow bulbs E, G, and J to lie vertically under bulb B. The filling mark D has been shifted from just below bulb B to a position on tube C opposite mark H. A short length of tube (about 10 mm) is shown between bulb B and tube C. This is the same size as tube A and may be omitted if it has no bearing on the glass blowing involved in bulb B. Bends in the capillary tube C, opposite mark K, and before the entry into bulb E, must be kept smooth and even because sudden changes in direction within and near the entrance to the capillary tube will reduce the effective range of the viscometer. All tube and bulb sizes and viscometer type numbers are given in Method D 445.[1]

The placing of bulbs F, G, and J vertically under bulb B reduces considerably the variation of the viscometer constant C that can be caused by inaccurate vertical alignment procedures. In this respect, this viscometer has the same characteristics as the Cannon-Fenske viscometer for transparent liquids and the suspended level types of viscometers.

The original position of the filling mark D made it rather difficult to fill the viscometer because of the manipulation required to keep the liquid on the filling mark. Moving the filling mark down into the capillary tube reduces the rate of flow and makes it easier to fill the viscometer accurately.

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[1] ASTM Method of Test for Kinematic Viscosity, 1958 Book of ASTM Standards, Part 7, p. 201.

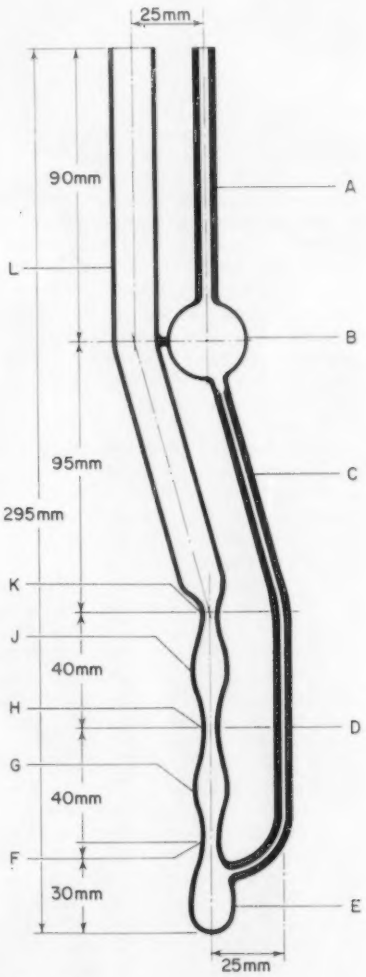

Fig. 1.—Modified Cannon-Fenske reverse-flow viscometer.

Design Criteria for 6Al-4V Titanium Alloy at Room and Elevated Temperatures

By M. M. LEMCOE and J. K. CHILDS

In order to establish structural design criteria for the 6Al-4V titanium alloy, tensile, compressive, bearing, and shear properties were determined on both bar and sheet material in the annealed condition at temperatures from 75 to 1000 F. In addition, tensile properties of sheet material were determined after 100-hr exposure at 600, 800, and 1000 F.

Results of these tests were compared with recently established minimum requirements for tensile strength in order to derive design values for strength in compression, bearing, and shear.

Other properties investigated include minimum bend radius for 105-deg bend and notched tensile strength at temperatures from 75 to 1000 F and torsional properties at room temperature.

The resulting design data is presented in tabular form and also in curves showing the effect of temperature on the various mechanical properties.

The program was sponsored by the Materials Laboratory, Wright Air Development Center.

The pressing need in the aircraft industry for a high-strength, lightweight material useful to 800 F has led to a surge of development work on titanium alloys. Among the more promising of the alloys under study is the 6Al-4V titanium alloy, which has a mixed alpha-beta microstructure. This type of alloy is distinguished by high tensile strength at elevated temperatures, good thermal stability, and high hydrogen tolerance. The 6Al-4V titanium alloy is available commercially in a range of wrought shapes from billets to sheet and can be heat treated to tensile strengths from 160,000 to 200,000 psi.

This test program was undertaken to provide not only the standard tensile strength information, but compression, bearing, and shear data as well, in a form useful to the designer. As planned, the program included testing mill-annealed bar and sheet from four production-run heats purchased from each of three producers, thus representing a sample of typical material likely to be purchased by any user.

Scope of Investigation

Material

The specific material ordered was $1\frac{1}{4}$-in. diameter bar and 0.063-in. sheet. As one producer was unable to supply 0.063-in. sheet at that time, the results for the sheet material are representative of two producers only. Heats were nonconsecutive and represented the range of production runs in chemical composition. Maximum hydrogen content was limited to 125 ppm for bar and 150 ppm for sheet. Minimum mechanical properties specified were 125,000 psi ultimate tensile strength, 115,000 psi yield strength, 10 per cent elongation, and 30 per cent reduction of area.

Mechanical Properties Investigated

The various properties determined from each type of test were:

1. Tension test of sheet and bar: yield and ultimate tensile strength, elongation, modulus of elasticity in tension, and, for the bar material only, reduction of area and notched tensile strength ($K_t = 3$).

2. Compression tests of sheet and bar: compressive yield strength and modulus of elasticity in compression.

3. Bearing tests of sheet and bar: yield and ultimate bearing strength for e/D ratios of 1.5 and 2.0, where e/D represents the ratio of distance from the

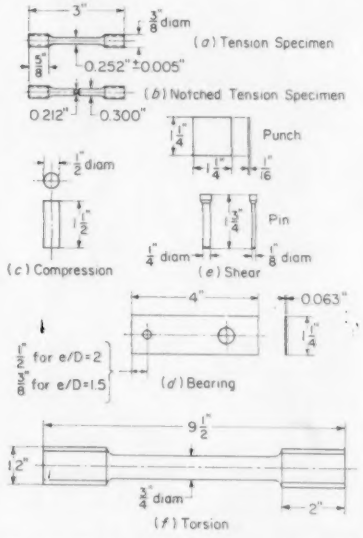

Fig. 1.—Bar material specimens ($\frac{1}{2}$ scale).

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center of the hole to the edge to hole diameter.

4. Shear tests: ultimate shear strength.

5. Bend tests: minimum radius for 105-deg bend.

6. Torsion tests: yield strength, modulus of rupture, and modulus of rigidity.

These properties were obtained at 75, 200, 400, 600, 800, and 1000 F after ½-hr exposure at test temperature, with the exception of the torsion tests which were performed at room temperature only. To investigate the effect on tensile strength of prolonged exposure to elevated temperatures, sheet materials were exposed at 600, 800, and 1000 F for 100 hr prior to testing at both ambient and the exposure temperature. Half of this latter group of test specimens were unstressed while undergoing the exposure treatment while the other half were stressed to one third the yield strength at the exposure temperature. All tests on sheet material were performed in specimens cut both parallel and transverse to the direction of rolling.

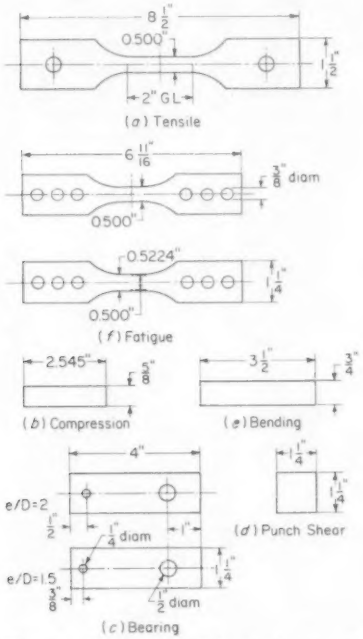
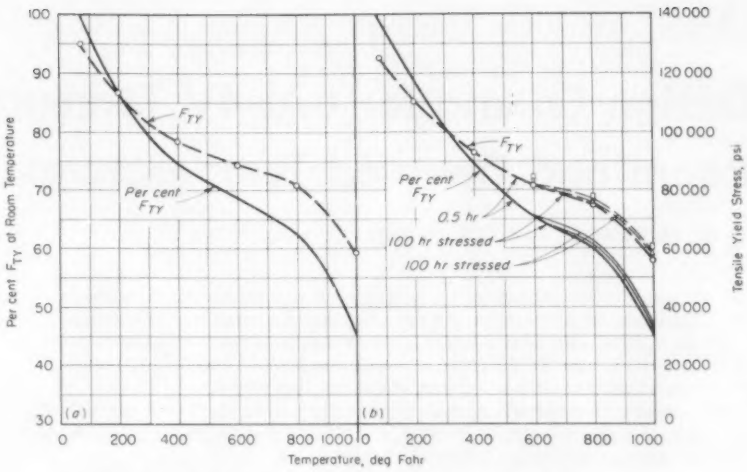


Fig. 2.—Sheet material specimens (½ scale).

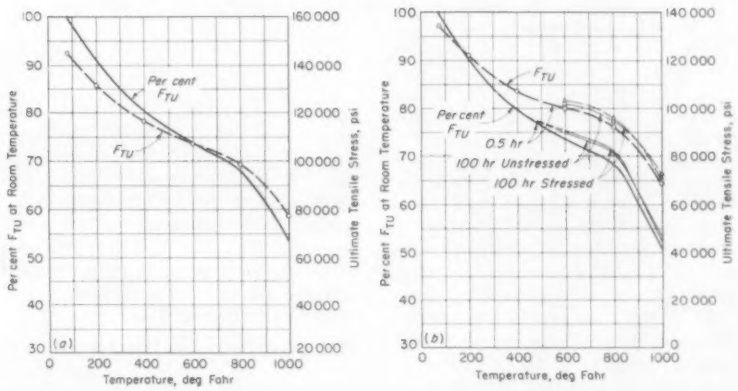
Specimens

Fabrication of all specimens was performed with strict adherence to close tolerances in an effort to minimize this variable in the test results, particularly with respect to the compression and bearing tests. The various types of specimens used are illustrated in Figs. 1 and 2. Sheet-type bearing specimens were milled from the center of the bar material for comparison with the sheet



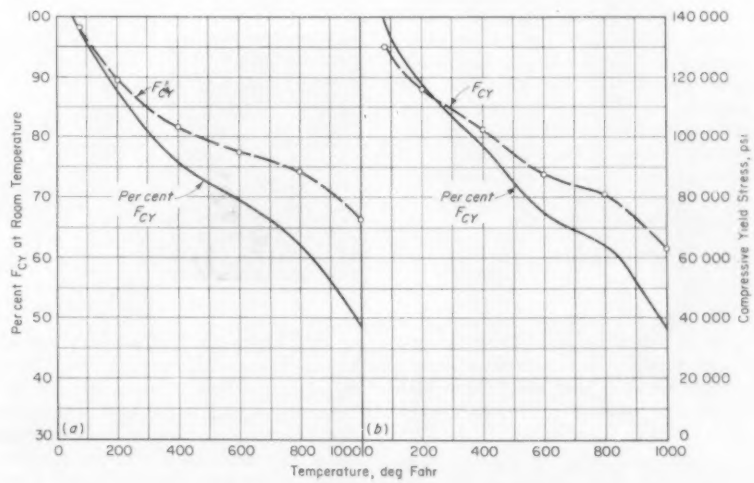
(a) Alloy bar. (b) Alloy sheet.

Fig. 3.—Tensile yield strength of 6Al-4V titanium alloy at elevated temperatures.



(a) Alloy bar. (b) Alloy sheet.

Fig. 4.—Ultimate tensile strength of 6Al-4V titanium alloy at elevated temperatures.



(a) Alloy bar. (b) Alloy sheet.

Fig. 5.—Compressive yield strength of 6Al-4V titanium alloy at elevated temperatures.

specimens. As a pin-type specimen could not be made from the sheet material, punch-type specimens were made from both sheet and bar for correlation with results from pin shear specimens made from the bar material.

Test Equipment

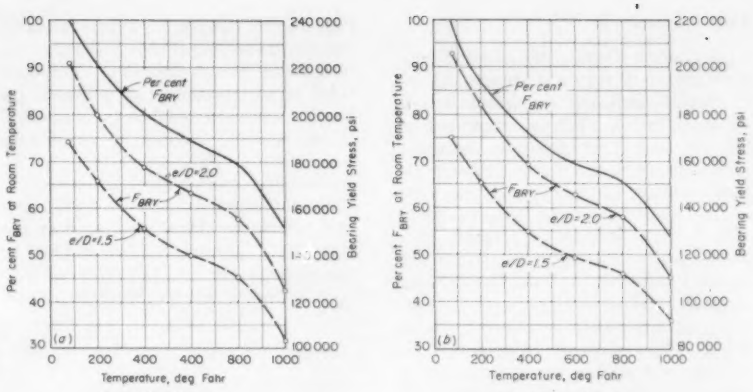
All tests, other than torsion, were performed in a 200,000-lb universal testing machine equipped with an autographic recorder and strained pacer. A strain rate of 0.005 in. per in. per min was maintained through yield on all tests where deformation was measured with a microformer-type high-temperature extensometer. In conjunction with the testing machine, a specially designed forced circulation furnace was used to heat the specimens to the desired temperature. Very accurate temperature control was achieved by use of a Leeds & Northrup electronic proportional controller-recorder with the control thermocouple mounted on or adjacent to the test section of the specimen.

A specially designed combination aging oven and loading apparatus was built to expose sheet specimens to elevated temperatures for 100 hr prior to tension testing, while under zero axial stress or a stress equal to one third the yield stress at the exposure temperature. In the loading apparatus, "strings" of pin-connected specimens were fixed at one end and loaded through a 5:1 multiplication bell crank and dead weight system. The specimen strings were enclosed in an oven. A wire rack beneath the strings of stressed specimens supported the unstressed specimens. With special reflector baffles, it was possible to maintain uniformity of temperature of all specimens within ±1 per cent at 1000 F.

The test fixtures were designed and fabricated to accommodate the various types of specimens. Prime objectives in their design were accuracy of alignment in loading and ease of removal of tested specimens and installation of new ones while the fixture was in the furnace.

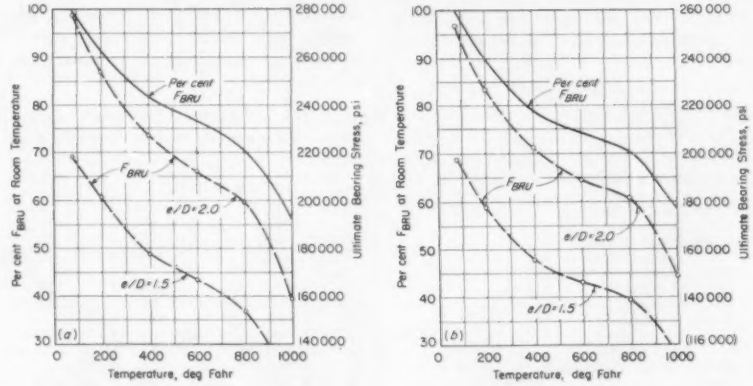
Torsion tests of bar material were conducted in a standard Olsen torsion testing machine with 50,000 in-lb capacity. Twist readings were taken with a troptometer having graduation of 0.01 in. at a distance of 11.48 in. from the center of twist or 0.0009 radian.

Extensometers used in tension, compression, and bearing tests were O. S. Peters microformers with extension arms suitable for the various specimens. At room temperature, deformation of one of each group of three specimens tested in tension and compression was measured with Tuckerman optical strain gages. Errors introduced by the adapter necessary for use of the optical gages at elevated temperatures were objectionable; hence, microformers were used al-



(*a*) **Alloy bar.** (*b*) **Alloy sheet.**

Fig. 6.—Bearing yield strength of 6Al-4V titanium alloy at elevated temperatures.



(*a*) **Alloy bar.** (*b*) **Alloy sheet.**

Fig. 7.—Ultimate bearing strength of 6Al-4V titanium alloy at elevated temperatures.

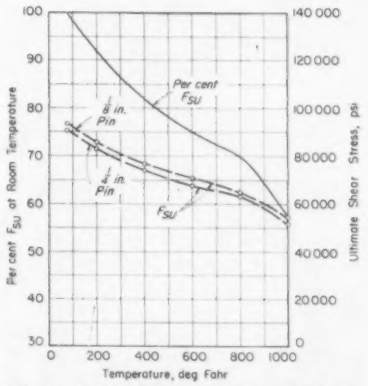


Fig. 8.—Ultimate bearing strength of 6Al-4V titanium alloy sheet at elevated temperatures

together at elevated temperatures. Accuracy checks at room temperature showed that the microformer extensometer repeatedly gave results for the modulus of elasticity within ±1 per cent of the average of two optical strain gages mounted in opposite sides of the tension specimens and within ±2 per cent for compression. This degree of accuracy could not be maintained for the bar compression specimens tested at 800 and 1000 F because of the difficulty in centering the specimens exactly while wearing thick asbestos gloves. However, even under these conditions, errors introduced by misalignment did not exceed ±5 per cent.

Test Procedures

The various tests performed were set up to reproduce the specified conditions as closely as possible. A minimum of three tests were performed on each heat of material for each condition. Before actual testing was started, each fixture was set up in the furnace with a dummy specimen equipped with several calibrated thermocouples spaced along its gage section. The control thermocouple was placed in the location to be used in testing. Distribution of temperature was checked and the control temperature varied until the correct temperature was attained within ±3 F, throughout the test section. The controller settings thus determined for each test and temperature condition were then used in subsequent testing.

After careful measurement of specimen dimensions and marking of the gage section, where applicable, the specimen was placed in the loading fixture and the extensometer attached. The specimen was then brought up to test temperature and held for ½ hr prior to testing.

Test Results

The curves showing the effect of temperature on the various properties investigated indicate consistent trends common to all. Tensile, compressive, bearing, and shear strengths decreased progressively with increasing temperature, showing a loss of 20 to 25 per cent in the ranges from room temperature to 400 F. The decrease in strength continued, but to a lesser extent, in the 400 to 800 F interval, the loss at 800 F being an additional 10 to 15 per cent. However, an increase in temperature from 800 to 1000 F reduced strength to 45 to 55 per cent of the room temperature value. Of the various properties investigated, tensile yield strength is the most severely reduced by increasing temperature. Exposure at elevated temperatures for 100 hr prior to testing had very little effect on the tensile properties of this alloy. Tensile strength was somewhat improved at the expense of a slight loss in ductility. The ductility of this material, as indicated by tension tests and bend tests, is affected in an unusual manner by increasing temperature. As temperature is increased from room temperature to 400 F, elongation and reduction of area increase and minimum bend radius decrease normally. However, at 600 and 800 F, elongation is reduced to values equal to or less than room temperature values. Reduction of area and minimum bend radius also exhibit reversals from the normal trend at 600 F. When temperature is increased from 800 to 1000 F, ductility shows a sharp increase proportionate to the decrease reflected in tensile strength values.

With the establishing of guaranteed minimum strength requirements for annealed 6Al-4V titanium sheet, plate, and bar stock, the results of tests for other mechanical properties have been related to these minimum requirements in order to establish design criteria.

The guaranteed minimum strength requirements are:

6Al-4V Titanium	Tensile Strength, psi	Yield Strength, psi	Elongation, per cent	Reduction of Area, per cent
Sheet and plate	130 000	120 000	10.0[a] in 2 in.	..
Bar	130 000	120 000	10.0 in 1 in.	25

[a] 0.063 and heavier; 8.0 per cent for lighter gages.

The design mechanical properties listed in Table I were determined from the minimum requirements by establish-

TABLE II.—SUMMARY OF TEST RESULTS.

TENSILE PROPERTIES (0.5 hr Exposure Time)

Test Temperature	75 F	200 F	400 F	600 F	800 F	1000 F
Tensile Yield Stress, psi:						
Bar	129 900	113 200	97 000	89 400	82 100	58 800
Sheet, longitudinal	124 800	110 600	93 100	81 500	74 600	56 000
transverse	130 400	114 900	98 300	86 000	78 400	58 300
Ultimate Tensile Stress, psi:						
Bar, unnotched	145 100	131 700	116 400	107 400	98 900	77 800
Bar, notched, $K_t = 3.0$	224 900	205 400	180 600	163 400	152 200	120 000
Notched ultimate	1 550	1 560	1 550	1 520	1 540	1 540
Sheet, longitudinal	134 500	122 100	107 300	99 900	92 100	68 900
transverse	133 800	120 800	106 500	98 200	92 100	71 900
Modulus of Elasticity, psi:						
Bar	16.0×10^6	15.3×10^6	14.1×10^6	13.3×10^6	12.2×10^6	9.1×10^6
Sheet, longitudinal	15.4×10^6	14.6×10^6	13.9×10^6	13.2×10^6	11.8×10^6	7.5×10^6
transverse	16.4×10^6	15.6×10^6	14.9×10^6	14.1×10^6	12.6×10^6	8.4×10^6
Ductility:						
Bar, unnotched						
Reduction in area, per cent	44.1	48.0	54.2	52.9	56.4	77.9
Elongation, per cent in 1 in.	16.4	17.6	18.9	17.1	20.2	38.4
Bar material, notched						
Reduction in area, per cent	10.6	13.5	18.2	21.3	24.2	37.4
Elongation, per cent of notch width	15	18	22	25	30	45
Sheet, elongation, per cent in 2 in.						
Longitudinal	13.6	15.0	15.1	13.1	17.0	32.1
Transverse	13.6	14.5	14.1	12.3	13.6	27.9

SHEET TENSILE PROPERTIES (100 hr Exposure Time)

Exposure Temperature	600 F		800 F		1000 F	
Exposure Stress	$\frac{F_{ty}}{3}$	0	$\frac{F_{ty}}{3}$	0	$\frac{F_{ty}}{3}$	0
Tensile Yield Stress, psi:						
Room-temperature tests						
Longitudinal	127 200	128 200	128 500	130 500	126 900	133 000
Transverse	132 100	133 600	133 700	136 000	131 200	137 300
Tests at exposure temperature						
Longitudinal	81 300	81 800	75 600	76 500	57 300	58 300
Transverse	85 400	86 200	79 200	79 800	58 800	59 000
Ultimate Tensile Stress, psi:						
Room-temperature tests						
Longitudinal	140 500	139 400	140 300	140 100	138 500	139.4
Transverse	138 500	138 400	140 100	140 400	139 000	139.2
Tests at exposure temperature						
Longitudinal	103 000	102 700	95 300	95 600	71 500	72.0
Transverse	100 900	100 500	95 300	94 900	72 800	73.2
Modulus of Elasticity, psi:						
Room-temperature tests						
Longitudinal	$15\,600 \times 10^6$	$15\,600 \times 10^6$	$15\,600 \times 10^6$	$15\,500 \times 10^6$	$15\,400 \times 10^6$	$15\,400 \times 10^6$
Transverse	$16\,800 \times 10^6$	$16\,700 \times 10^6$	$16\,600 \times 10^6$	$16\,700 \times 10^6$	$16\,500 \times 10^6$	$16\,600 \times 10^6$
Tests at exposure temperature						
Longitudinal	$13\,600 \times 10^6$	$13\,800 \times 10^6$	$11\,900 \times 10^6$	$11\,700 \times 10^6$	$7\,600 \times 10^6$	$7\,600 \times 10^6$
Transverse	$14\,500 \times 10^6$	$14\,700 \times 10^6$	$12\,700 \times 10^6$	$12\,900 \times 10^6$	$8\,300 \times 10^6$	$8\,100 \times 10^6$
Elongation, in 2 in., per cent:						
Room-temperature tests						
Longitudinal	13.0	13.1	13.5	13.6	11.6	12.2
Transverse	13.0	12.9	13.5	13.4	12.6	11.9
Tests at exposure temperature						
Longitudinal	13.1	12.6	15.5	15.8	30.0	30.4
Transverse	12.1	12.2	12.5	12.6	26.0	27.2

ing ratios of average room-temperature test values for compression and bearing yield strength to tensile yield strength, and bearing and shear ultimate strenth to tensile ultimate strength. The ratios determined by tests were then related to the appropriate minimum tensile strength in order to derive minimum values for the other mechanical properties investigated. To illustrate, the minimum compressive yield strength was derived as follows:

$$\text{Minimum } F_{cy} = \text{Minimum } F_{ty} \left(\frac{\text{Test } F_{cy}}{\text{Test } F_{ty}}\right)$$

The minimum values thus established were conservative except in the case of sheet material from one producer. At the time this material was purchased, the minimum requirements specified were 115,000 psi tensile yield and 125,000 psi tensile ultimate. Since that time, manufacturing techniques have improved to the extent that this producer can now guarantee the more recently established minimum tensile strength values.

TABLE I.—DESIGN MECHANICAL PROPERTIES OF 6AL-V4 TITANIUM ALLOY SHEET AND BAR.

(See Appendix for symbols listed in this table.)

Type	Direction	Bar	Sheet
Condition	...	Annealed	Annealed
Thickness, in.	...	1½-D	0.063
Basis	...	A	A
F_{tu}, psi	L	130 000	130 000
	T	...	130 000
F_{ty}, psi	L	120 000	120 000
	T	...	120 000
F_{cy}, psi	L	126 000	126 000
	T	...	126 000
F_{su}, psi	...	80 000	76 000
$F_{bru}(e/D = 1.5)$, psi		196 000	191 000
$F_{bru}(e/D = 2.0)$, psi		248 000	244 000
$F_{bry}(e/D = 1.5)$, psi		174 000	163 000
$F_{bry}(e/D = 2.0)$, psi		205 000	198 000
e, per cent	...	10	10
E_t, psi	L	16 000 000	15 400 000
	T	...	16 400 000
E_c, psi	L	16 400 000	16 000 000
	T	...	16 900 000
F_{st}, psi	...	110 000	...
G, psi	...	6 200 000	...
Minimum bend radius (105-deg bend)		...	4T
w, lb per cu in.		0.160	0.160

Using the values listed in Table I as 100 per cent at room temperature, curves showing the effect of temperature on the various mechanical properties were determined. These curves are presented as Figs. 3 through 8. In the case of sheet material, which was tested both in the longitudinal and transverse directions, the curves were based on the results of tests of longitudinal specimens, since greater strength was exhibited in the transverse direction in all types of tests

Bearing tests at e/D ratios of 1.5 and 2.0 showed virtually the same ratio of elevated-temperature strengths in relation to their respective room-temperature strengths. Thus both of these conditions have been combined into one curve which may be used in conjunction with the room-temperature bearing strength listed in Table I for either e/D ratio.

The value for ultimate shear strength of sheet material listed in Table I was derived by applying the relationship between values of punch shear strength for bar and sheet material to the ultimate strength obtained in tests of ¼-in.

TABLE II—SUMMARY OF TEST RESULTS. (*continued.*)

Test Temperature	75 F	200 F	400 F	600 F	800 F	1000 F
Compressive Properties						
Compressive Yield Stress, psi:						
Bar	136 200	119 100	102 900	94 700	88 300	72 500
Sheet, longitudinal	130 500	116 000	102 700	87 900	81 200	63 300
Transverse	138 100	121 000	105 700	92 800	85 000	64 600
Modulus of Elasticity, psi:						
Bar	16.4×10^6	15.4×10^6	14.3×10^6	13.7×10^6	12.7×10^6	9.1×10^6
Sheet, longitudinal	16.0×10^6	14.8×10^6	14.2×10^6	13.3×10^6	12.2×10^6	8.1×10^6
Transverse	16.9×10^6	15.9×10^6	15.2×10^6	14.3×10^6	13.2×10^6	9.1×10^6
Bearing Properties						
Bearing Yield Stress, $e/D = 2.0$, psi:						
Bar	221 500	199 800	177 600	166 600	155 700	124 900
Sheet, longitudinal	205 400	183 900	158 200	145 500	135 800	110 200
Transverse	212 700	190 300	164 200	147 400	141 200	112 000
Bearing Yield Stress $e/D = 1.5$, psi:						
Bar	188 100	171 900	151 000	139 900	130 700	103 800
Sheet, longitudinal	170 000	150 500	129 500	118 100	111 600	91 700
Transverse	173 100	151 500	130 400	120 700	112 400	91 700
Ultimate Bearing Stress, $e/D = 2.0$, psi:						
Bar	277 200	253 900	227 000	212 100	199 300	158 000
Sheet, longitudinal	253 500	226 900	202 600	189 300	181 600	149 000
Transverse	260 800	238 800	211 300	195 800	187 700	157 000
Ultimate Bearing Stress, $e/D = 1.5$, psi:						
Bar	218 500	201 400	177 600	166 900	153 800	121 000
Sheet, longitudinal	197 200	177 800	155 600	146 400	138 800	115 500
Transverse	206 600	185 300	164 000	156 400	144 900	121 800
Shear Properties						
Ultimate Shear Stress, psi:						
Bar, ¼-in. diameter pin	90 600	83 200	74 100	67 900	63 300	52 000
⅛-in. diameter pin	93 700	85 900	77 100	71 100	64 900	54 700
Punch type	101 400	94 000	84 900	82 400	75 900	62 300
Sheet, punch type	96 600	89 800	84 700	80 900	75 400	60 700
Torsion—Yield Stress, psi	78 500	...	...	...	...	...
Modulus of Rupture, psi	123 500	...	...	...	...	...
Modulus of Rigidity, Psi	6.18×10^6	...	...	...	...	...
Minimum Bend Radius, 105-deg Bend						
Sheet, longitudinal	3.75T	3.34T	2.31T	2.38T	1.91T	0.66T
transverse	4.00T	3.44T	2.16T	2.41T	1.91T	0.28T

diameter pins made from bar material. To illustrate:

$$F_{su}^{1}\ (\text{Sheet}) = F_{su}\ (\text{Bar-Pin Type Tests}) \times \frac{F_{su}\ (\text{Sheet-Punch Type Tests})}{F_{su}\ (\text{Bar-Punch Type Tests})}$$

The value for $\frac{1}{4}$-in. diameter pins was used both in establishing the sheet ultimate shear strength and in Table I because it was lower than the strength of the $\frac{1}{8}$-in. diameter pins and would thus be more conservative.

Higher ultimate stresses are obtained from the punch-type shear test than can be expected in pure shear as determined in pin shear tests. The curve in Fig. 8 is based on data obtained in tests of $\frac{1}{4}$-in. diameter pins at elevated temperatures, but is also applicable to the tests of $\frac{1}{8}$-in. diameter pins as the effect of temperature on ultimate strength of the two sizes of specimens is virtually identical.

Table II is a summary of the test results. For bar material, each value listed represents the average of 36 tests, while for sheet material each value is the average of 24 tests. Test values are also shown as dashed lines on the curves in Figs. 3 through 8.

Conclusions

The conventional short-time elevated-temperature properties of the 6A1-4V titanium alloy were determined for conditions of tension, compression, bearing, and shear, and were reduced to a form suitable for design criteria. In addition, the effect on the tensile properties of sheet material of exposure at elevated temperatures for 100 hr was found to be negligible, thus indicating good thermal stability.

Results of the test program indicate that tensile yield and ultimate strengths were more severely reduced by increasing temperature than the other properties investigated, particularly at 1000 F. However, the tensile strengths presented are nominal, based on original specimen area. Specimen deformation during tension testing, especially at 1000 F, is more pronounced than in the other types of tests. Comparison of the other properties with true tensile stresses, determined from actual specimen area at the yield and ultimate loads, would in all probability show a more uniform relationship at all temperatures.

The variation in strength found in tests of material from different producers was probably caused by the production techniques employed at the time of manufaeture of the material tested in this program. With increased experience on the part of the producers with this relatively new material, constant improvement of techniques should result in standardization of material and even better mechanical properties.

[1] This is an estimation of what the ultimate shear strength would have been from a pin-shear type test of the sheet material.

Acknowledgment:

This investigation was conducted in the Structures Research Laboratory of the Department of Engineering Mechanics, Southwest Research Inst., in cooperation with Wright Air Development Center under Contract AF 33(616)-3548. This paper summarizes results reported in WADC Technical Report 58-246, which contains detailed descriptions of test apparatus and procedures as well as all test data.

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APPENDIX

Symbols

D = diameter.
E_c = modulus of elasticity in compression.
E_t = modulus of elasticity in tension.
F_{bru} = ultimate bearing stress.
F_{bry} = bearing yield stress.
F_{cy} = compressive yield stress.
F_{st} = modulus of rupture in torsion.
F_{su} = ultimate shear stress.
F_{tu} = ultimate tensile stress.
F_{ty} = tensile yield stress.
G = modulus of rigidity.
GL = gage length.
K_t = theoretical factor of stress concentration.
e = elongation in per cent (in Table I), or, minimum distance from hole centerline to edge of sheet (in bearing tests).
w = specific weight, lb/cu. in.
t = sheet thickness

Measurement of Surface Moisture and Sulfur Dioxide Activity at Corrosion Sites

By P. J. SEREDA

THE RATE OF corrosion of a steel specimen based on a day of wetness has been found to correlate with the measured temperature of the specimen and the sulfur dioxide atmospheric pollution rate (1).[1]

Detection of surface moisture was made possible by the development of a suitable sensing element described in earlier reports (2, 3). The amplifier suitable as a field instrument, designed by the Division of Radio and Electrical Engineering for use with this sensing element, is described here.

Sulfur dioxide activity was measured by the lead peroxide method (4), which gave an average value per day of exposure. For correlation with corrosion rate, the value required is that corresponding to the activity during periods when wetness occurs on the exposed specimens, which may or may not be the same as the average value. A method is presented whereby this can be accomplished.

Experimental

The d-c amplifier to operate with the moisture-sensing element was designed to serve the purpose for which the pH recorder was used (2, 3). A satisfactory design was achieved while maintaining the necessary simplicity. The detailed circuit diagram is given in Fig. 1.

The amplifier has its own calibrating circuit which feeds to the input 0 to 0.4 v, thus enabling the instrument to be preset to trigger the output relay at the desired input voltage. This calibrating device enables easy checking of the instrument in case any drift of the response occurs. The off-on differential is about 0.03 v.

This amplifier has an input impedance of about 10 megohms, and for this reason it was necessary to use a sensing element having two platinum electrodes on each face in order to retain the desired sensitivity.

Two amplifiers, each coupled with a Haydon elapsed-time indicator ED72-001, were used to record the hours of wetness on the skyward and groundward exposures from which the time-of-wetness was obtained.

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[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

This is the final report on measurement of surface moisture carried out at the Division of Building Research and the Division of Radio and Electrical Engineering, National Research Council, Canada. This project was initiated by the Task Group on Measurement of Atmospheric Factors of ASTM Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys.

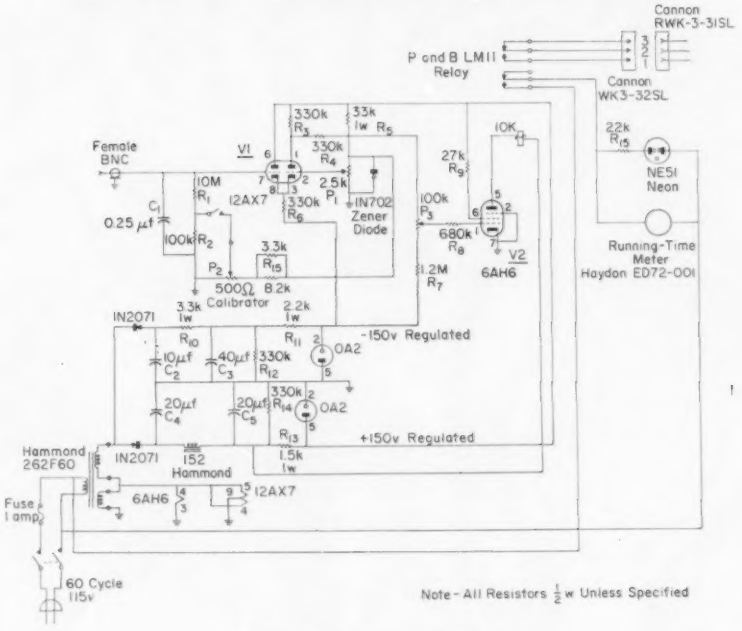

Fig. 1.—Dew detector amplifier.

The lead peroxide cylinder and screen were modified to permit the uncovering of the cylinder during periods of wetness and to shield the cylinder during dry periods. The complete assembly, called the sulfur dioxide shield, is shown in Fig. 2. It consisted of an aluminum cup which was lifted by means of a reversible, 6-v, d-c motor operating through a rack and pinion.

This apparatus was electrically coupled with the amplifier and moisture-sensing element in such a way that the lead peroxide cylinder was exposed only during the periods when moisture was detected on the groundward side of the sensing element. The complete schematic wiring diagram is shown in Fig. 3. The amplifier and elapsed-time indicator were in a heated hut; the sensing element, the sulfur dioxide shield, and lead peroxide cylinder were located outdoors on the exposure site where corrosion of steel was being observed.

The lead peroxide cylinder that was exposed continuously was located beside the one that was exposed during wetness periods so that the two values could be compared.

P. J. SEREDA, associate research officer, Division of Building Research National Research Council, Ottawa, has been engaged since 1950 in the study of the behavior of water in porous systems including methods of detecting and measuring the presence of water on surfaces of materials.

TABLE I.—CORROSION EVALUATION DATA OBTAINED AT OTTAWA.

		Dw[a]	Monthly Mean Air Temperature, deg Fahr[b]	Sulfur Trioxide, mg per sq dm per day		
				ACCRP[c] Corrosion Site, Average	DBR[d] Property Site, Average	DBR[d] Site, Wet Periods
1958	Oct.	15.4	46.5	0.42	1.44	2.01
	Nov.	15.1	36.5	0.65	1.16	1.03
	Dec.	21.1	9.4	0.83	2.19	2.73
1959	Jan.	11.8	12.9	1.13	1.89	2.83
	Feb.	12.7	10.3	1.02	1.95	1.91
	Mar.	7.15	24.0	0.69	2.05	2.89
	Apr.	7.35	43.8	0.66	1.59	2.37
	May	8.35	58.5	0.45	0.60	0.15
	June	6.85	66.3	0.44	0.65	0.68
	July	4.00	72.2	0.30	0.25	0
	Aug.	8.30	72.0	0.30	0.48	0.63
	Sept.	9.75	62.3	0.29	0.45	0.42
	Oct.	13.5	45.9	0.44	1.82	2.55
	Nov.	17.6	32.6	0.67	2.18	2.48

[a] Day of wetness (groundward exposure).
[b] Obtained by The Meteorological Service.
[c] NRC, Associate Committee on Corrosion Research and Prevention.
[d] NRC, Division of Building Research (sites [c] and [d] 800 yd apart).

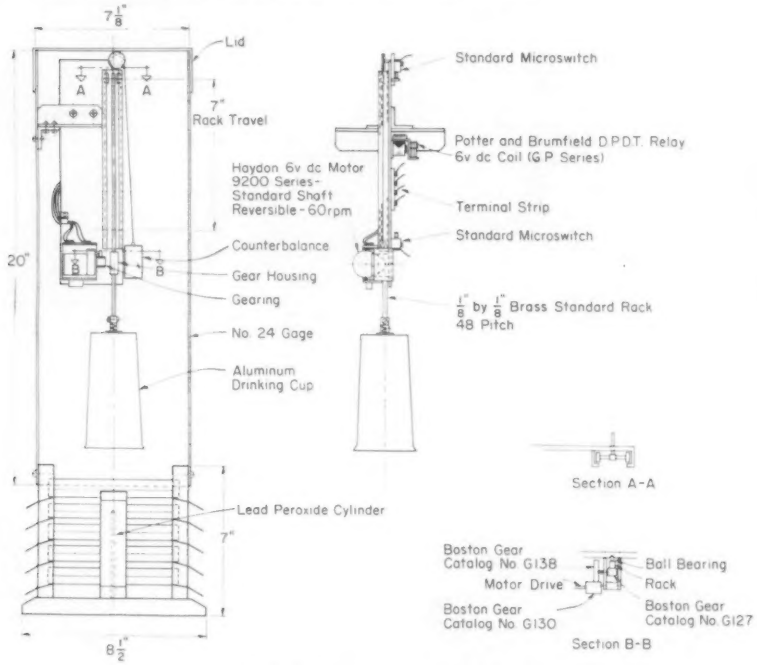

Fig. 2.—Sulfur dioxide shield.

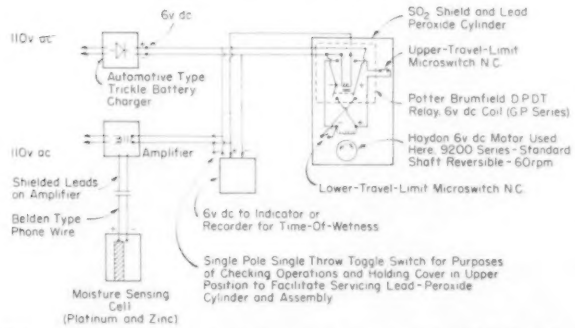
6v dc
110v ac
Automotive Type Trickle Battery Charger
SO2 Shield and Lead Peroxide Cylinder
Upper-Travel-Limit Microswitch N.C.
Potter Brumfield D.P.D.T. Relay, 6v dc Coil (G.P. Series)
Haydon 6v dc Motor Used Here, 9200 Series-Standard Shaft Reversible-60rpm
110v ac
Amplifier
Shielded Leads on Amplifier
Lower-Travel-Limit Microswitch N.C.
6v dc to Indicator or Recorder for Time-Of-Wetness
Belden Type Phone Wire
Single Pole Single Throw Toggle Switch for Purposes of Checking Operations and Holding Cover in Upper Position to Facilitate Servicing Lead-Peroxide Cylinder and Assembly
Moisture Sensing Cell (Platinum and Zinc)

Fig. 3.—Wiring diagram for the time-of-wetness meter and sulfur dioxide shield.

Results

It is apparent from Table I that, for some months, the difference in sulfur dioxide activity was large between periods of wetness and the whole time. This probably depends on proximity of the source of pollution and its location relative to the prevailing wind direction during wetness periods. It would appear that these measurements would be useful where the sites are located near sources of pollution, especially if the values are to be used for correlation with the rate of corrosion of metals.

Because the time-of-wetness for any given month may vary twofold from one year to the next, it seems worth-while to locate this instrumentation to measure the hours of wetness and the corresponding sulfur dioxide activity at all the corrosion sites so that conditions affecting the corrosion would be known for any period of exposure.

The rate of corrosion of an exposed specimen is affected by the average temperature of the specimen during its wetness period (1). An accurate value of this temperature can be obtained by recording the temperature sensed by a thermocouple placed on the groundward side of the specimen. The recorder can be started by the amplifier when moisture is first detected, and stopped at the completion of the wetness period. An approximate value of the desired temperature can be obtained by measuring the air temperature during the wetness periods. During the months when the time-of-wetness is greater than 15 days, it has been shown (1) that the monthly mean air temperature as obtained by the Meteorological Service differed by less than 4 deg Fahr from the average temperature of the specimen during the wetness periods. Thus, in many instances, especially if the data are to be used on a yearly basis, the air temperature as obtained by the Meteorological Service may be adequate for use in evaluation of the rate of corrosion.

Acknowledgments:

The amplifier described here and shown in Fig. 1 was designed by R. I. Mott of the NRC Division of Radio and Electrical Engineering. The instrumentation was set up and operated by H. F. Slade, and the analyses for sulfur dioxide were made by C. C. Barrett. The author is grateful for their assistance. This paper is a contribution from the Division of Building Research, of the National Research Council, Canada, and is published with the approval of the Director of the Division.

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Measurement of the Brittleness Temperature of Polyethylene*

By A. M. BIRKS and A. RUDIN

It is well known that polyethylene retains its flexibility even at fairly low temperatures. In common with other plastics that are flexible and tough at room temperature, however, it does tend to become more brittle as the temperature is lowered. Since polyethylene cable, pipe, and injection moldings are sometimes used under cold conditions, several test methods have been developed to measure the effect of temperature on impact resistance of the plastic. These tests usually employ compression-molded test specimens which are chilled to different temperatures and then struck or bent rapidly. A sample is normally characterized by its "brittleness temperature," defined as that temperature at which 50 per cent of the specimens tested failed when subjected to the specified test conditions.

ASTM Tentative Method of Test for Brittleness Temperature of Elastomers by Impact (D 746)[1] involves the use of specimens die-punched from compression-molded sheet. The testing apparatus, which is commercially available, consists essentially of an insulated box containing a clamping arrangement for the specimens and a motor- or solenoid-driven striking arm. Specimens are brought to the required temperature by cooling or heating the bath liquid in which they are immersed. Commercial units, as received, contain rather rudimentary temperature control equipment, so operation of the method is laborious and the precision of its results suffers from the uncertainty in test temperature.

Specimens, tested five at a time, are clamped as cantilever beams, brought to the required temperature and struck by a hammer moving at a linear speed of 6 to 7 ft per sec at impact. The proportion of the five bars which fail under impact is converted to a percentage and plotted on probability paper against the corresponding temperature. When sufficient experiments have been carried out, a straight line is drawn through the scatter of temperature-per cent failure points. The 50 per cent failure temperature is read from this line.

TABLE I.—BRITTLENESS TEMPERATURE DATA ACCORDING TO METHOD D 746.

		Brittleness Temperature, T_b, deg Cent Polyethylene					
Laboratory		A	B	C	D	E	F
1[a]		−68	−100	−94	−46	− 99	−96
2	Not annealed[b]	−85	−101	−94	−65	−105	−91
2	Annealed[c]	−46	− 77	−63	−36	− 76	...

[a] Specimens annealed for 10 min in boiling water before testing.
[b] Specimens tested as pressed, without annealing.
[c] Specimens annealed 1 hr in boiling water.

Operation of this test method in the described manner can lead to very variable results. With polyethylene this is illustrated by the data in Table I, which were chosen from test figures obtained after different annealing procedures at two laboratories in our company. The concurrence between brittleness temperature data is so poor, in general, that the test method appears to be unsuitable for defining specification levels. The main objective of the work reported here was therefore the elimination of discrepancies between the test results from different laboratories.

There was also much room for improvement in the efficiency of the test, particularly as regards reduction of the amount of work and extraction of the most information from the test data. A major requirement was for a reliable fast-acting temperature controller. It was also thought desirable to develop a testing procedure which would require a minimum number of experiments and eliminate the intuitive element in the drawing of the per cent failure-temperature line used to find the brittleness temperature. A further advantage would be realized if the test procedure were such that it could be carried out entirely by a technician without supervision.

Summary of Modified Test Method

The objectives listed above were realized by modifying some of the details of Method D 746.[2]

Modifications which have been made include:

1. An efficient temperature controller which acts from room temperature to −110 C.
2. Elimination of molding variations by a postmolding conditioning pro-

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* Presented to Subcommittee VIII, ASTM Committee D-20, Washington, D. C., Feb. 19, 1959.

[1] ASTM Method of Test for Brittleness Temperature of Plastics and Elastomers by Impact (Tentative) (D 746), 1958 Book of ASTM Standards, Part 9, p. 355.

[2] A copy of the modified method and detailed drawings are available from the authors.

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cedure, which seems to be applicable, and necessary, for almost all mechanical testing of compression-molded polyethylene (1),[3]

3. Avoidance of specimen cutting errors (2) by the use of notched test specimens. (This modification provides the added benefit of a sharply reduced scatter of test results for specimens from a single sample.),

4. Provision of accurate clamps to prevent wedging of the specimens,

5. A change in the criterion by which a specimen is judged to have failed, and

6. A revised testing procedure whereby an unsupervised technician can operate the whole test and extract an accurate brittleness temperature from fewer data. This procedure also results in faster operation, by reducing the number of temperature settings required in the test.

The modified method is not considered to be a new test; it merely achieves the objectives which were implied but not realized in Method D 746. Even the use of a deliberate notch does not change the fundamental character of the test, since brittleness temperatures measured by Method D 746 have apparently always been influenced by surface imperfections (2).

Details of Modified Test Method

Apparatus

The temperature-control apparatus, mounted on a Tinius-Olsen motor-driven brittleness tester, is shown in Figs. 1 to 3.

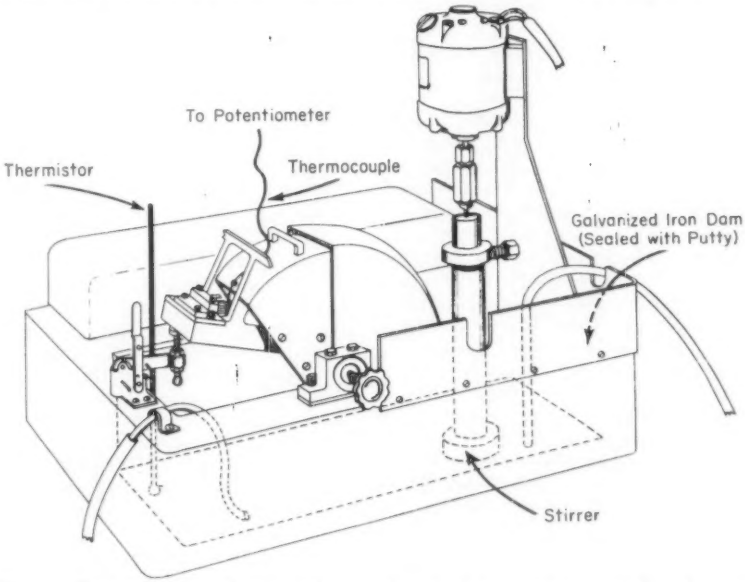

Fig. 1.—Test apparatus, showing stirrer and part of temperature control equipment.

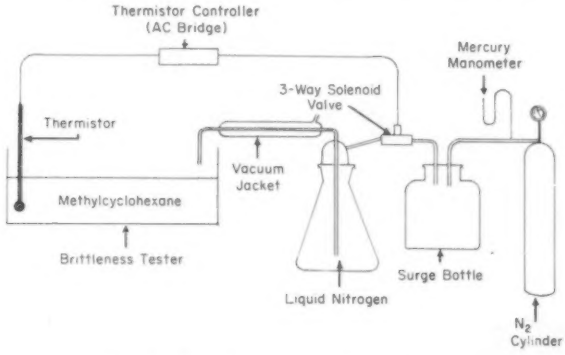

Fig. 2.—Liquid nitrogen cooling system.

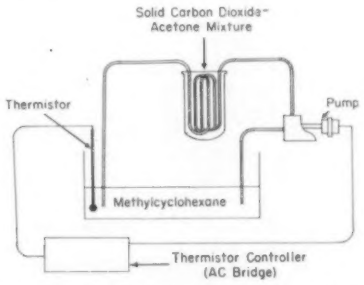

Fig. 3.—Solid carbon dioxide cooling system.

The instrument can be used from room temperature to about −110 C. It can be operated by one man and will maintain a given temperature to better than ±1.0 C. Temperature changes can be effected very rapidly; the bath can be cooled from room temperature to −30 C in less than 30 min.

The temperature controller is constructed as follows. Bath temperature is sensed by a thermistor connected to an a-c bridge in the thermistor controller. A variable resistance in one arm of the a-c bridge can be adjusted to equal the resistance of the thermistor at any desired temperature. (The temperature-resistance curve for the particular thermistor must be determined beforehand.) So long as the bath is warmer than the required temperature, the bridge is out of balance and the controller signals for cooling. The bath is cooled automatically either by dropping liquid nitrogen onto the surface of the bath liquid (methylcyclohexane) or by pumping the bath liquid through a solid carbon dioxide reservoir.

When the bath is colder than required it warms by heat exchange with its surroundings. An immersion heater can be used to speed up the warming process, which is not controlled automatically.

Two alternative systems, (*a*) based on liquid nitrogen and (*b*) solid carbon dioxide, are used. Liquid nitrogen may be used to reach any temperature down to about −110 C, when the methylcyclohexane bath liquid begins to freeze. The solid carbon dioxide arrangement is suitable only for temperatures warmer than about −60 C.

Liquid Nitrogen Cooling System (*Fig. 2*).—When the thermistor controller signals for cooling, the solenoid valve opens and nitrogen pressure forces liquid nitrogen onto the surface of the bath. This automatic, intermittent addition of liquid nitrogen suffices to hold any preset temperature to ±1 C.

The bath must be very vigorously stirred to prevent local freezing at the liquid nitrogen inlet. The stirrer shown in Fig. 1 provides violent agitation. The sheet-metal dam shown attached to the top of the bath, in Fig. 1, controls splashing by the stirrer.

Working temperatures can be changed rapidly with this arrangement. The bath can be cooled from +30 to −30 C in about 25 min. Consumption of liquid nitrogen is not excessive; the unit has been operated for 4½ hr at −30 to −60 C using 15 liters of coolant.

Solid Carbon Dioxide Cooling System (*Fig. 3*).—In this case a

[3] The boldface numbers in parentheses refer to the list of References appended to this paper.

tube runs from the brittleness tester bath through a pump, a coil cooled by solid carbon dioxide in alcohol, and back to the bath. The pump, which is connected to the thermistor controller in place of the solenoid valve in the preceding setup, operates intermittently to keep the bath temperature at a level preset by the controller. The stirrer shown in Fig. 1 is run continuously to minimize temperature gradients in the bath. The carbon dioxide unit holds a desired temperature rather more precisely than the liquid nitrogen apparatus, but it does not cool the bath as quickly.

Sample Molding and Conditioning

Test specimens are compression-molded and conditioned by the method described in a preceding paper (1). The reasons for introducing a postmolding sample conditioning step, the requirements which such a conditioning procedure must fulfill and the method whereby these requirements were met were discussed in that paper. Examples quoted there showed that a sample conditioning procedure of the type described is necessary to prevent molding variations from affecting the interlaboratory precision of brittleness temperature test results. The method consisted, briefly, of compression-molding polyethylene plaques, remelting them to erase their thermal histories, and then cooling the plates at a controlled rate from above the melting point to room temperature. Two cooling rates were generally used, a slow cooling at 5 C per hr and a fast rate, in which molten plates were quenched in cold water, under standard conditions. The reader should note that there is often a pronounced difference between the brittleness temperatures of annealed and quenched samples of the same resin. This matter is discussed more fully in subsequent sections of this article.

Specimen Cutting

The use of test specimens containing a controlled notch eliminates the serious errors due to variations in specimen cutting (2). Notched specimens also result in a reduced scatter of results and apparently more realistic brittleness temperature figures.

Work by Hoff and Turner (2) and Bestelink and Turner (3) showed that the brittleness temperature test for polyethylene is actually a notch test. The brittleness temperatures obtained by both the Imperial Chemical Industries (ICI) and ASTM test methods were shown to be affected by surface imperfections inadvertently produced by specimen-cutting tools. Specimen-cutting must be very carefully controlled if precise brittleness temperature figures are to be obtained.

TABLE II.—ELIMINATION OF SPECIMEN-CUTTING EFFECTS BY USE OF NOTCHED SPECIMENS.

Specimens[a]	Specimen-Cutting Method	Brittleness Temperature of Specimens Notched After Cutting, T_b deg Cent, 50 per cent failure
A	Knife cut	−28
	Knife cut, followed by rubbing with emery paper	−28
	Die cut	−24
B	Knife cut	−17
	Knife cut, followed by rubbing with emery paper	−18
	Die cut	−19
C	Knife cut	−20
	Knife cut, followed by rubbing with emery paper	−22
	Die cut	−23

[a] Specimens not conditioned.

It was decided to use notched specimens in this work because of the demonstrated effectiveness of this method (2) and because brittleness temperatures measured on notched specimens would probably be more realistic than those derived from specimens with smooth surfaces. Polyethylene articles in use usually have scuffed or scratched surfaces, and impact failures in the field are probably aggravated by surface defects.

The notch is made in the narrow edge of the specimen. When the broad faces of the specimens are notched, the brittleness temperature is very sensitive to notch depth; edge notches are not nearly so sensitive.

To be effective, the notch must be located exactly at the point where the specimen is bent over the anvil during impact. This is at the lip of the clamp used in Method D 746. The most effective way to locate the notch at the lip of the clamp appeared to be to clamp the specimens first and then notch them. A simple, useful notcher is shown in Fig. 4.[2,4]

The data in Table II show that notching eliminates the effects of variation in specimen cutting in the ASTM test method, just as it does in the ICI test (2). The magnitudes of the errors eliminated by deliberate notching are illustrated in Turner's paper (2). A standard notch depth of 0.02 in. gave reproducible brittleness temperature data.[5] Variation of notch depth up to about ±0.003 in. about the target does not appear to affect the test results.

Specimen Clamping

When notched conditioned specimens are used, the brittleness temperature may be sensitive to stress variations caused by misalignment of the two parts of the clamp. The clamps ordinarily supplied with the testing machine do not appear to be aligned accurately enough for precise work. Precision clamps useful for this test are shown in Fig. 4.[2]

Criterion of Failure

The notch always extends when the specimen is struck. The following criterion for failure has been found to be suitable. After the impact, the operator removes the clamp from the testing machine and bends each remaining specimen. Any specimen that does not spring back to its original shape within a few seconds is counted as having failed. This criterion differs from that proposed by Webber (4), since here only complete separation or a "hinge break" is counted as a failure. A partial break, crack, or hole is not counted as a failure unless the specimen is so badly broken that it cannot restore itself to its original shape. This criterion also differs from that of Hoff and Turner (2) who count only complete separation as failure.

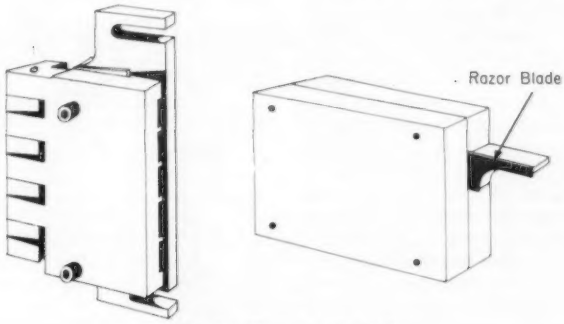

Fig. 4.—Clamps and notcher.

There seems to be no theoretical reason for preferring one standard over another so long as each is internally consistent and gives precise results. The one described above has been found to be suitable for Method D 746, using notched, conditioned specimens.

Scatter of Test Results and Testing Procedure

Using the procedure described, the scatter of results within a single test is much reduced from that characteristic of Method 746. This scatter is meas-

[4] This notcher gives equivalent results to the pliers described before (see footnote to title), but is easier to make and use.

[5] Notch depth was erroneously reported as 0.035 in. in a preliminary description of this test method (see footnote to title).

ured by the standard deviation of distribution of failures, which is closely equal in this case to the temperature interval corresponding to a change of 34 per cent in the proportion of failures (1). A small standard deviation of distribution of failures indicates that transition from ductile to brittle behavior took place over a narrow temperature range. Since the brittleness temperature quoted is a median figure, its value for describing a material improves as the temperature interval between few and many failures decreases.

In the modified D 746 test method described here, use of notched conditioned test specimens produces test results in which the standard deviation of distribution of failures is 1 to 2 C. This feature permitted a simpler, faster testing procedure than in Method D 746. The modified test measures the proportion of failures accurately at only two temperatures. One temperature is such that 20 to 50 per cent failures are observed and the other such that 50 to 80 per cent are found. These two temperature-per cent failures points are used to define the straight line from which the 50 per cent failure temperature is read. The operator finds a temperature at which the per cent failures is between 20 and 80 per cent and tests 25 specimens (5 trials) there. Since the standard deviation of distribution of failures is known beforehand, he can simply change the temperature by an appropriate amount in the right direction and complete the test with another five trials under the latter conditions. (An experienced operator can do as well with 20 specimens (four trials) as with 25.) The testing time, after specimens are conditioned and cut, is not more than 1 hr per sample, since there are relatively few temperature changes.

Test Results

Interlaboratory Reproducibility

The poor interlaboratory precision of Method D 746, illustrated in Table I, was an important reason for starting the present work. The results of a round-robin trial of the modified procedure described here, between three laboratories in our company, are shown in Table III. These results, when contrasted with those of the original method in Table I, indicate that good interlaboratory reproducibility is possible. There are no significant differences between laboratories at the 95 per cent level of confidence. The 95 per cent confidence limits for the first three entries in Table III are ±5.4 C. This means that any one laboratory could expect, with 95 per cent confidence, that another group would reproduce its data to within 5.4. C The last eight entries, between two laboratories, were measured after more experience had been gained with the test. Here the 95 per cent confidence limits are closer to ±4 C. The data indicate that the modified test method is suitable for control and specification work.

TABLE III.—INTERLABORATORY PRECISION OF MODIFIED D 746 BRITTLENESS TEMPERATURE TEST.

Specimen[a]	Cooling Cycle during Specimen Preparation[b]	Temperature for 50 per cent Failure, F_{50}, deg Cent					
		Laboratory 1		Laboratory 2		Laboratory 3	
		F_{50}	Standard Deviation[c]	F_{50}	Standard Deviation[c]	F_{50}	Standard Deviation[c]
B1	Fast-cooled[c]	−40	2.4	−35	1.6	−35	2.6
	Slow-cooled[d]	− 2	5.8	− 6	2.8	− 5	2.0
B2	Fast-cooled[c]	−58	2.0	−60	3.0	−55	1.7
	Slow-cooled[d]	−16	2.5	...	...	−16	1.7
B3	Fast-cooled[c]	−19	0.6	−22	1.3	−23	1.0
	Slow-cooled[d]	+ 1	2.1	− 3	1.7	+ 3	0.0
B4	Fast-cooled[c]	−39		...		−37	
B5	Fast-cooled[c]	−25		...		−26	
B6	Fast-cooled[c]	−13, −15		...		−13, −14	
B7	Fast-cooled[c]	−42		...		−40, −43	
B8	Fast-cooled[c]	−24		...		−23	
B9	Fast-cooled[c]	−41		...		−39	
B10	Fast-cooled[c]	−15		...		−17	
B11	Fast-cooled[c]	−17		...		−20	

[a] All specimens were Type I (ASTM D 1248).
[b] Details of specimen preparation are given in Ref. (1).
[c] Fast-cooled: molten specimens quenched in cold water, under standard conditions.
[d] Slow-cooled: molded plates cooled from the melt temperature at 5 C per hr.
[e] σ = standard deviation of distribution of failures. It indicates the temperature interval over which transition from ductile to brittle behavior occurred. For all practical purposes, σ in this case = $F_{84} - F_{50} = F_{50} - F_{16}$, where, for example, F_{84} is the temperature for 84 per cent failure.

TABLE IV.—DIFFERENCES BETWEEN SLOW- AND FAST-COOLED SPECIMENS—BRITTLENESS TEMPERATURE.

Specimen[a]	Brittleness Temperature, deg Cent	
	Fast-cooled[b]	Slow-cooled[c]
717	−45.6	− 6.2
754	−43.7	−12.5
712	−41.9	− 7.3
727	−35.4	− 7.8
X1 (melt index 2)	−51	−19
Y1 (melt index 7)	−50	...
Z1 (melt index 20)	−43	−10

[a] All specimens were Type I (ASTM D 1248). See (1) for details of preparation.
[b] Fast-cooled: molten specimens quenched in cold water, under standard conditions.
[c] Slow-cooled: molded plates cooled from the melt temperature at 5 C per hr.

Effect of Notching

The use of notched specimens raises the brittleness temperature about 40 to 50 C compared to that of unnotched D 746 specimens. The actual change depends on the particular sample. The notch also contributes greatly to the reduced scatter of results within a single test.

Effect of Cooling Rate During Sample Preparations

When the rate of cooling from the melt temperature is changed, the corresponding variation in brittleness temperature will depend on the particular resin which is being tested. This change can be very large, and can completely overshadow melt index and density considerations. Examples of this effect are shown, for some low-density polyethylenes, in Table IV.

Significance of Test Results

This test method measures the resistance of notched specimens to a specified impact as a function of temperature. A more complete description of a resin is provided by samples prepared by cooling from the melt at a variety of rates.

The texture (5) of annealed samples will approximate that of polyethylene articles a relatively long time after their fabrication by normal methods and of new articles that have been cooled slowly during fabrication. Quenched specimens will be more like articles freshly made by the usual methods of extrusion or injection molding. Neither of the postmolding conditioning methods used in this work was intended to be a duplicate of commercial conditions. They are extremes, rather, and the condition of fabricated articles will probably lie between those produced by these two procedures.

A comparison of the brittleness temperature of quenched and annealed samples of the same resin will indicate how articles made from this polymer will tend to change on aging and how they will be affected by variations in cooling rates during their formation. These changes may be quite large, as shown by the values in Table IV. These data illustrate the general rule that the choice of the conditioning process can swamp the melt index effect over a large melt index range.

The sensitivity of the brittleness temperature of polyethylene to its thermal history limits the practical application of test results. Variations in forming conditions can have a tremendous influence on the brittleness temperature of an article and the results of this test cannot therefore reflect lowest usage temperatures for different polyethylenes.

It should be borne in mind, moreover, that the main reason for introducing sample conditioning was to prevent confusion of test results by variations in specimen preparation between laboratories (1). The choice of the two conditioning methods used here was influenced by the desire to improve the practical usefulness of the test results, but this was a secondary consideration. A comparison of brittleness temperatures of fast- and slow-cooled specimens should help to characterize a resin, but it cannot tell the whole story, since the specimens are essentially free of the molded-in and applied stresses which polyethylene articles might suffer in use.

In summary, while these test results are not suitable for direct engineering application, they can be useful for comparing different resins, provided the comparison is confined to forming processes which result in similar residual textures and stresses in the finished articles. It is hoped that the value of these test results will increase with experience in correlating them with field behavior.

Acknowledgments:

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An Improved Microhardness Tester for High-Temperature Use*

By J. H. WESTBROOK

Microhardness testing is not only an efficient but frequently the only means for obtaining information on the temperature dependence of strength of hard, brittle materials. Design problems become more formidable as one seeks to test more brittle materials at higher temperatures and lower loads.

The design, construction, and operation of an improved high-temperature microhardness tester are described. Testing is done *in vacuo;* other specifications include: temperature range, −190 to 1500 C; load range, 5 to 1000 g; rate of loading, 0.2 to 1.2 mm per min; time of indentation, 2 to 60 sec. Examples of various applications of the instrument are given to demonstrate its capabilities and the variety of problems for which it may be used.

THE ADVANTAGES of microindentation hardness testing for studying the strength-temperature behavior of materials have recently been reviewed (1).[1] This same paper described an instrument with a load range of 20 to 900 g, a temperature range of 20 to 1500 C, and manual control of loading by means of an air-actuated hydraulic system. While that instrument has provided a large volume of useful data, several years' experience indicated three aspects of its operation that needed further improvement.

Brittle materials exhibit extreme sensitivity to loading rate with respect to cracking incidence and apparent hardness. The hydraulic loading system formerly used was able to maintain neither as smooth a rate of loading nor as low a rate as seemed to be required to obtain reliable data on such brittle materials as quartz or the interstitial carbides. In addition, the method of operation of the original instrument was rather inefficient, especially when a number of specimens were to be studied at the same temperature. The main chamber cooled very slowly under vacuum; therefore specimens once indented could not be extracted from the device and the indentations measured until several hours had elapsed (usually overnight). Furthermore, at times the limited capacity of the specimen magazine slowed the execution of a series of tests. Finally, the fact that the loading was performed manually introduced an undesirable personal variability as well as operator fatigue.

It was decided that the desired improvements in the method of loading could be achieved with a motor drive that would raise the specimen against a dead-weight-loaded indenter mounted on a counterbalanced beam, a design principle common to a number of commercial room-temperature microhardness testers. Inclusion of vacuum locks at both entrance and exit ports would permit the specimen to be readily inserted and removed with the test chamber pumped down and at temperature. Provision of a series of contacts, relays, and timers would automate the indenting operation. This paper reports the construction, operation, and application

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author or authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

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[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

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of an instrument embodying these features and covering the same load and temperature range as in the earlier instrument.

Description of the Apparatus

General

A photograph and a schematic diagram of the apparatus are shown in Figs. 1 and 2. Aside from the loading system and automatic control, other features of the instrument (the general arrangement, specimen size, furnace design, temperature measurement, and vacuum system) are similar to those in the equipment previously described. Noteworthy details or differences are discussed below.

To operate the instrument, a specimen is introduced through the entrance port and vacuum lock (*19*), lowered onto the entrance chute, and pushed into the chamber with the push rod. The push rod has free motion in the first part of the traverse for introduction of the specimen in the test chamber; a fine screw adjustment (*20*) permits positioning of the specimen in the test chamber to ±0.1 mil.

After the specimen (*14*) is heated to the desired temperature or allowed to equilibrate with the existing furnace temperature, a loading weight (*11*) is chosen from a set of six within the vacuum chamber and a series of indentations made. A single push button actuates the whole indentation and reset cycle, the specimen being advanced a small distance between indentations. After all desired indentations have been made, the specimen is pushed out the exit chute into the extraction chamber (*22*) and the vacuum lock (*23*) closed. The water-cooled ejector permits extraction of the specimen within a few minutes, following which the indentations can be measured at room temperature with a microscope equipped with a filar eyepiece. The correction for thermal contraction is commonly neglected.

Particular attention was paid in the design of the instrument to ease of disassembly for interchange of indenters, replacement of the furnace core or thermocouple, and selection of load. In addition, several large viewing ports were incorporated for visual observation of the operation of the various components.

Furnace and Associated Components

A V-10 General Radio Variac driving a pair of current transformers provides a maximum input power of 1.5 kw at 30 amp and 50 v, with stepless control over the whole temperature range. As before, an internal vertically wound furnace core (*25*) was used with radiation heat shielding (*24*). A temperature of 1500 C could be attained with about 1200 w. For studies below room temperature, a small bath could be placed on the anvil (*15*) and the specimen immersed directly in an appropriate cryostatic fluid. In this instance, temperatures other than fixed points were measured with an auxiliary copper-constantan thermocouple.

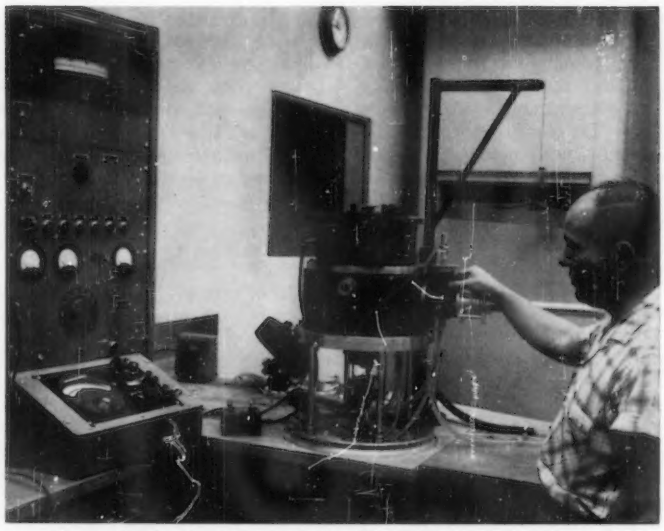

Fig. 1.—High-temperature microhardness tester and control panel.

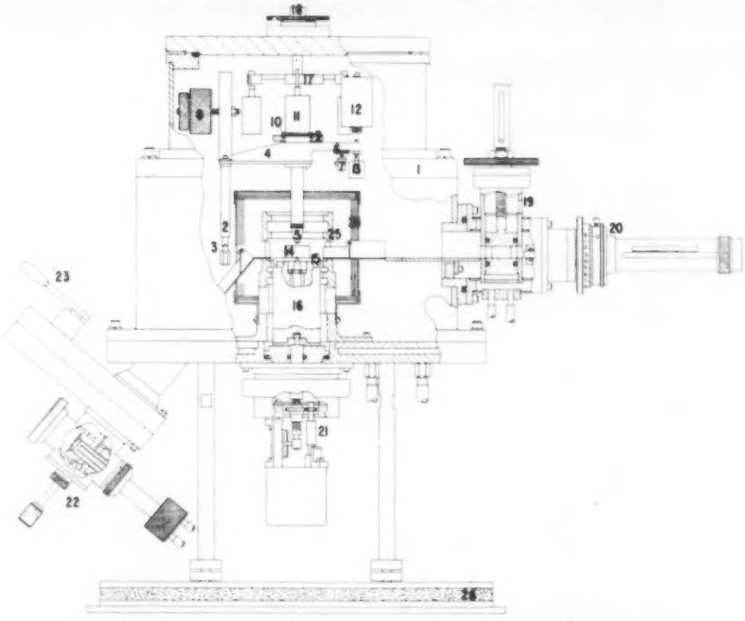

Fig. 2.—Schematic diagram of high-temperature microhardness tester.

Indenter

The indenter assembly is designed to provide firm and rigid attachment to the loading beam and yet minimize heat flow along the indenter to the beam. The indenter itself is mounted in a removable head so that indenters of various materials or geometries may be conveniently interchanged. As discussed previously (**1**) specimen-indenter interaction is a very serious problem in high-temperature microhardness testing and is the principal factor fixing the upper temperature limit for this type of test. The most satisfactory indenter materials have been found to be diamond, sapphire, and titanium diboride; the latter is not available commercially in single-crystal form.

Loading System

The indenter load is applied to the specimen by raising the specimen against the indenter mounted on a balanced beam. To clarify the more detailed description which follows, attention is directed to Fig. 3, a phantom view of the beam assembly in a plastic jig.

All components of the beam assembly are mounted on the periphery of an open base plate (here represented by the clear plastic plate (*1*)) of the upper section of the main testing chamber. This whole section can be readily removed as a unit from the main chamber, thus facilitating maintenance and change-over of the loading system.

A pivot frame (*2*) locates the pivots (*3*) for the beam (*4*) external to the furnace case and in the same horizontal plane as the indenter tip (*5*). The pivot points are a knife-edge and cone pivot and seat combination which limits any motion of the indenter tip to a planar arc. In the rest position the beam (*4*) is held in the horizontal plane by an adjustable contact point (*6*) which rests on a beam support (*7*). The weight of the beam and indenter is counterbalanced by an adjustable weight (*8*). The beam and indenter is counterbalanced by an adjustable

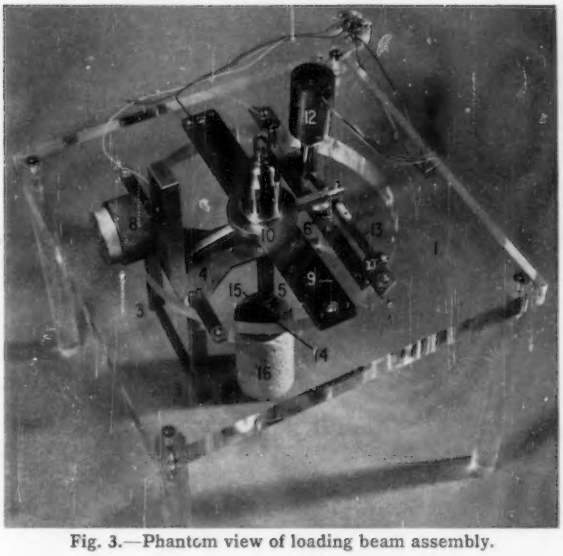

Fig. 3.—Phantom view of loading beam assembly.

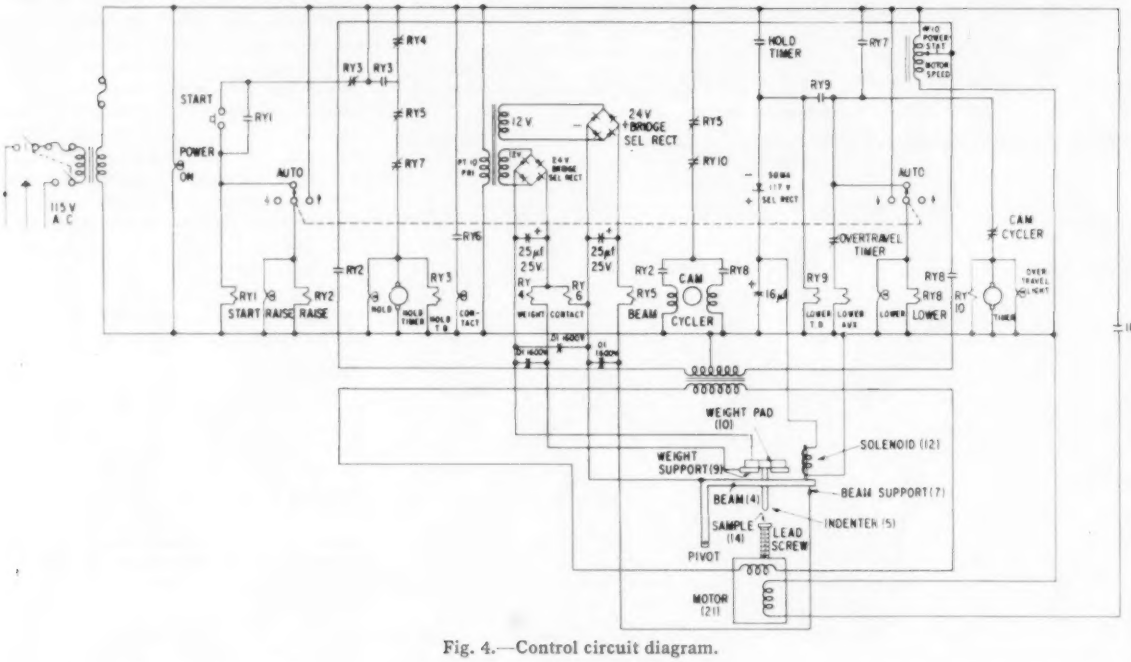

Fig. 4.—Control circuit diagram.

weight (*8*). The beam is intentionally not completely counterbalanced, as this would result in too much instability despite the vibration-isolation pad on which the instrument is mounted. The residual weight of the beam (usually 5 g) thus constitutes a preload applied prior to the main load. A special boss on the beam (*4*) projects through a circular hole in the weight support (*9*), so that as the indenter is raised by the specimen the weight pad (*10*) and the weight (*11*) are picked up by the beam. The load applied is thus the total of the preload, the weight pad, and the weight itself. The weight pad is used as an electrical contact point so as to eliminate the need for contact on each of the individual weights. Vertical travel from the point of indenter-specimen contact to full pickup of weight and weight pad is restricted to a few mils by careful adjustment of the contact point (*6*). At the end of the indentation period a solenoid (*12*), operating through a lever arm (*13*), raises the beam and the indenter until the specimen can be lowered to the start position. Wiring is run from the various contact points to the control circuit to be described below.

The specimen (*14*) sits on a molybdenum anvil (*15*) which, in turn, rests on a refractory pedestal (*16*). Loading of the specimen is achieved by vertical motion of this whole column by a geared-down synchronous motor ((*21*), Fig. 2), the speed of which is controlled by a panel-mounted rheostat. With the particular motor speed and gearing chosen, vertical-travel speed is continuously variable over the range from 0.2 to 1.2 mm per min.

As indicated above, any one of a set of six weights may be selected for use from outside the test chamber. In this way the load applied may be varied

from one specimen to the next, or even on a single specimen, without cooling down or opening up the test chamber. The standard set of weights permits loads of 50, 100, 200, 300, 500, and 1000 g. A load of 21.4 g is also available using only the weight pad, as well as a load of 5 g with the preload alone. The set of weights is suspended from a load spider (*17*) which is mounted through O-ring seals to the top plate of the upper section of the test chamber. These seals permit rotary motion for weight selection and sufficient vertical motion for lowering the selected weight onto the weight pad (*10*).

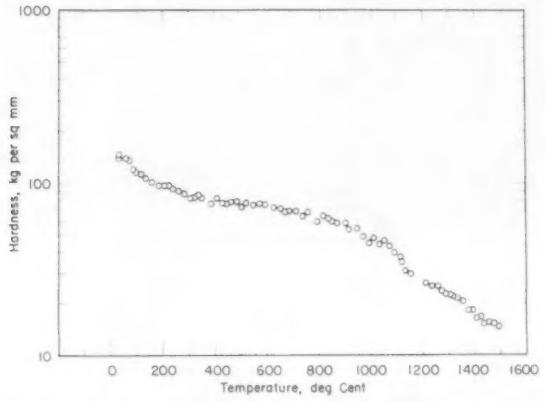

Fig. 5.—Temperature dependence of the hardness of molybdenum, room temperature to 1500 C.

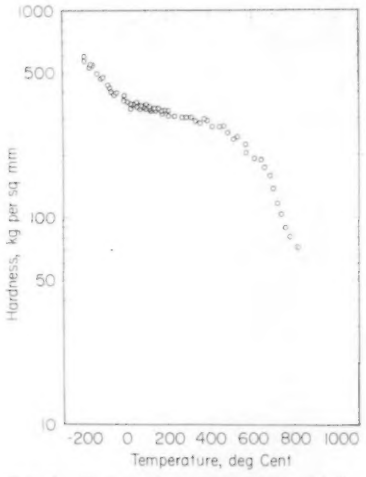

Fig. 6.—Temperature-dependence of the hardness of nickel-aluminum (61 atomic per cent nickel), liquid nitrogen to 800 C.

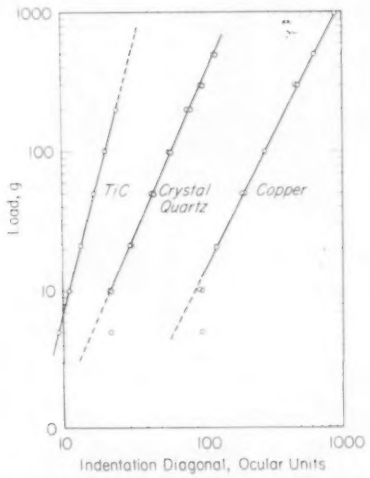

Fig. 7.—Loading tests on materials of three different hardness levels.

Control Circuit

Completely automatic operation of the loading cycle is secured through a system of contacts and relays. The circuit diagram is shown in Fig. 4 and may be described briefly as follows: Initially the weight pad (*10*) rests on the weight support (*9*), and the beam (*4*) on the beam support (*7*), so that both *RY4* and *RY5* are picked up. When the start button is pressed holding relay *RY1* closes, thereby energizing *RY2* whose contacts complete the circuit to the "raise" winding of the motor. The motor then raises the specimen toward the indenter by motion of the lead screw. When the specimen contacts the indenter it causes the beam to be lifted off the beam support, dropping out *RY5* and starting a cam cycler forward. (The purpose of the latter device is to enable automatic return of the specimen to a predetermined elevation, as described later.) The mechanical stops are adjusted so that vertical travel from this point to contact between beam (*4*) and weight pad (*10*) is restricted to a few mils. When the beam contacts the weight pad *RY6* is picked up, and almost immediately thereafter the weight pad (*10*) is lifted off the weight support (*9*), dropping out *RY5* and energizing the hold-timer and *RY3*. *RY3* will close in 1 sec if the weight stays off its support. (This arrangement is to prevent false starts of timing due to an imperfect contact.) When *RY3* closes it stops the motor and holds itself and the hold-timer energized; the cam cycler also stops. The hold-timer can be adjusted manually for any time between 2 and 60 sec; normally 15 sec is used. At the end of the hold period, the beam lifting solenoid (*12*) is energized as well as *RY9*, which closes after 1 sec. When *RY9* closes it energizes *RY7*, which in turn closes *RY8* and starts the motor (and thus the specimen) back down; *RY7* also locks this circuit in. Simultaneously the cam cycler is restarted in the reverse direction; upon returning to its initial position, it picks up the over-travel timer and stops itself through *RY10*. The purpose of the over-travel is to bring the specimen to an elevation slightly below the indenter contact point so that a lateral advance to a new position can be made without scratching. When the over-travel times out it drops out *RY7*, stopping the motor and dropping out everything else which was still energized. De-energizing the solenoid allows the beam to fall back onto its support. The circuit is now in its initial condition and after pushing the specimen to a new indentation site, the loading cycle may be repeated by again pushing the start button. A series of pilot lights on the control panel—"power on," "raise," "contact," "hold," "lower," and "over-travel"—apprise the operator of the course of operation of the cycle.

Application

The following examples of the applications of the instrument demonstrate both the range of parameters that may be used and the variety of problems that may be attacked in this way.

The temperature range available is shown in Figs. 5 and 6. Figure 5 presents results obtained up to 1500 C on a molybdenum specimen using a sapphire indenter. The usual two-segment semilogarithmic plot is obtained with no other noteworthy features. An example of studies below room temperature is given in Fig. 6 with data for a nickel-rich nickel-aluminum specimen. The deviations observed at low temperatures from the higher temperature extrapolation are attributable to the onset of a martensitic type of transformation to a body-centered tetragonal structure just below room temperature (**2, 3**).

One of the best ways of assessing the behavior of a microhardness instrument is to make a log-log plot of load against indentation diameter. If everything is as it should be the result will be a straight line. The various possible deviations from this and their origin

have been discussed previously (1). Examples of such tests made on the present machine are shown in Fig. 7. The results verify the applicability of the instrument over the claimed load range. Excessive cracking occurred in quartz above 500 g for the loading rate used (0.2 mm per min) and in titanium monocarbide above 200 g (1.2 mm per min). Deviation from linearity at 10 g and below for copper and 5 g and below for quartz are attributed to vibration and inertia effects. Since there is little need to operate at such low loads, no attempt was made to seek further improvement in this direction.

One of the objectives of the new design was to reduce the loading rate so that it would be possible to obtain hardness data on brittle materials with acceptably low scatter over a wide range of temperatures. Two examples are shown in Fig. 8 for a brittle oxide, quartz, and a brittle carbide, TiC. While still further improvement might be desired, particularly in the case of quartz, the temperature-dependence and the effects of the high-low inversion can be determined quite unambiguously.

Load variability furnishes a means for a semiquantitative measure of "brittleness" or cracking tendency as suggested by Ikornikova (4), Winchell (5), and others. Cracking tendency increases with increasing load and thus the load for a constant percentage of cracked indentations is a measure of the relative "brittleness" of individuals in a series of specimens. Since the indentations maintain similar geometry with changing load, and other loading conditions are kept constant, the percentage of cracked indentations is equivalent to the probability that a particular point in the specimen can sustain a certain effective strain without fracture.[2] The results of an extensive series of such tests on silica quartz over a range of temperatures and a 1 mm per min loading rate are shown in Fig. 9. Each point in the figure is based on a sample population of 20 indentations. Direct comparison of relative "brittleness" or "ductility" cannot be made from this plot since the effective sample size has inadvertently changed with temperature due to softening of the material. An approximate correction for this may be made taking as a measure of ductility, D, at any temperature, T, the ratio of the load, L, for 50 per cent cracking as measured at T to the product of the 50 per cent cracking load at some reference temperature, T_0, (for example, room temperature) and the ratio of the hardness values at T and T_0:

$$D_T = \frac{L_{T(50 \text{ per cent cracked})}}{L_{T_0(50 \text{ per cent cracked})}} \frac{H_T}{H_{T_0}}$$

[2] Tabor (6) has shown that for the 136-deg pyramid indenter the effective strain about an indentation is about 8 per cent.

The results of such treatment of the data of Fig. 9 are shown in Fig. 10. It is apparent that there are pronounced and probably complex effects of temperature and structure on the brittleness of quartz.

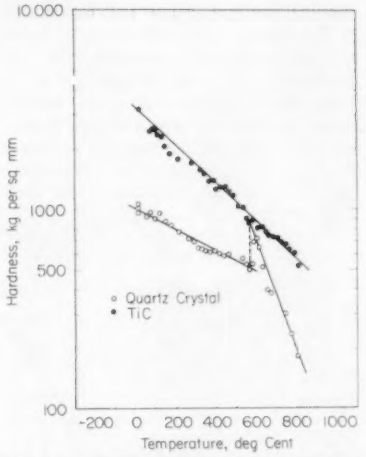

Fig. 8.—Examples of hardness-temperature runs on two brittle materials. Individual datum points are shown, not averages.

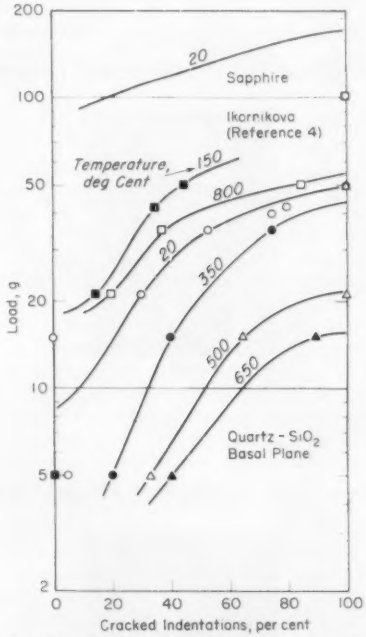

Fig. 9.—Effect of load on percentage of cracked indentations in quartz at various temperatures (7).

The problem of the variation in effective sample size can also be treated by testing at constant load and using loading rate as the independent variable. The rate for a given incidence of cracking at constant load then represents an inverse measure of cracking tendency. An example of this approach is shown in Fig. 11; sample populations of 20 indentations were again employed. It is perhaps worthy of note that for quartz the relation of cracking incidence to load rate is different in air than *in vacuo* as was used in the tests reported

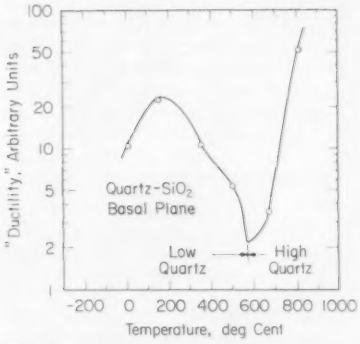

Fig. 10.—Reduced plot of data from Fig. 9, showing effect of temperature on ductility of a quartz single crystal (7).

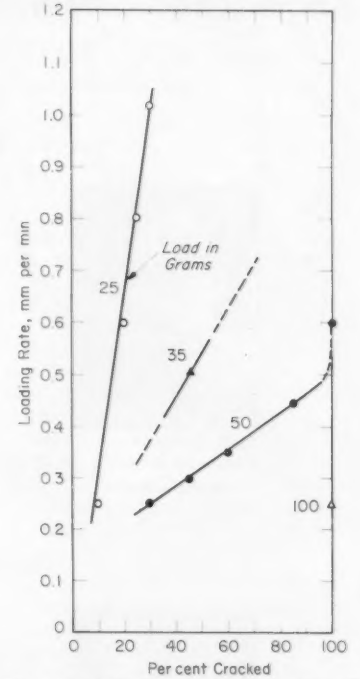

Fig. 11.—Effect of loading rate on percentage of cracked indentations in quartz at room temperature for various loads.

here. In air there is an optimum loading rate for minimum cracking incidence, apparently as a result of a stress-corrosion or "static fatigue" phenomenon.

As a final illustration of what can be done with this instrument, Fig. 12 is presented. In this instance a de-

tailed study of the temperature dependence of strength has been made on a specimen which measured only 1 by 2 by 3 mm; this is only one of several check runs made on the same specimen.

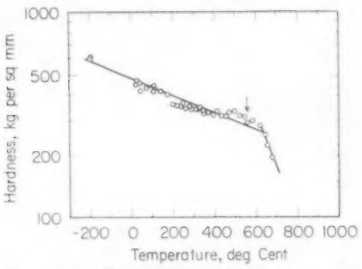

Fig. 12.—Temperature-dependence of hardness of high quartz, $LiAlSiO_4$ (high eucryptite) (7).

Acknowledgments:

The author is indebted to many members of the design section of the G. E. Research Laboratory for assistance with the mechanical design of the test instrument. The electrical control circuitry was developed in collaboration with F. C. Billingsley. A major contribution was made by Edwin Matthews, who was responsible for all phases of the actual construction of the instrument and also aided in its design. The test data reported to illustrate the capabilities of the instrument were all obtained by A. J. Peat, whose carefulness and patience were invaluable. Appreciation is also extended to the American Ceramic Society for permission to reproduce figures previously published in their Journal (7).

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In Defense of Committees

(Continued from p. 24)

engrossed in the Larger Things of Life, that the net result was disappointing, to say the least. The whole development, according to those who know, derived from individual efforts at solving some local problem for essentially selfish reasons. But finally, the mosaic, as we see it today, came forth, and we are quite proud of it; for all we know, the committees are still dreaming of that perfect world where every little strain gage fits into place as planned. As a matter of simple justice the committees must not be condemned too harshly; the situation clearly called for inventive genius, design ingenuity, and vigorous engineering and commercial development, none of which can be supplied by a committee.

Well, what the heck are committees good for! For one thing, we run our country with them. Committees of the Congress at the Federal level, and committees of the state legislatures advise the parent bodies what legislation should be enacted. If it weren't for committees, our legislative halls would be veritable Towers of Babel. To all intents and purposes, these committeemen advise the parent body as to what laws should be passed, amended, or revoked, and since we are a nation of laws, it follows that they are the backbone of our continued welfare. If they fail, then the whole mechanics of constitutional government, as we know it, would have to be overhauled.

In the executive and judicial branches, from the highest to the lowest levels, from head of government and highest courts to local magistrate, councilman, or village trustee, we find committees advising those who have original jurisdiction over, and responsibility for, our nation's welfare. The committee system in many cases is less formal than in the legislative branch but, nevertheless, plays a significant part in the country's affairs. Here again the service is advisory, leaving final decisions perforce to the elected or appointed official where they properly belong. So, for better or for worse, we depend on advisory committees in the operation of our nation. The many years they have worked is at the least a tribute to the system's durability, and in addition constitutes presumptive evidence of inherent goodness.

Corporations, too, are replete with committees. Notwithstanding that the management of a business must be authoritarian and the final decision rests with the big boss, he and his colleagues in top management must rely on committees for advice in many vital areas, such as long-range planning, personnel, salary structure, fringe benefits, labor relations, and a host of others, to say nothing of the technical aspects of running the business. No executive in his right mind presumes to be competent in every facet of his enterprise.

The jury that decides between imprisonment and liberty, or between life and death is a fact-finding committee of Anglo-Saxon heritage, and with all its faults we've found no better method of dispensing justice and equity. Even the Lord chose twelve men to continue His kingdom on earth. He might have chosen one; the skilled orator, the learned philosopher, the humble fisherman, the ubiquitous tax collector. Or indeed the one that betrayed Him thrice before the cock crowed. But He chose all twelve; the Lord's committee, as it were.

Nevertheless in such mundane matters as government, business, science, law, etc., why call in a committee? Why not ask some smart character to solve all the problems? In the first place, the smart one, be he ever so renowned, probably has less precise knowledge of the subject matter than the regularly elected or employed officials. Therefore we must accept the thesis that he will make up in erudition, acumen, judgment, and other attributes what he lacks in knowledge. But assuming we could locate the saintly Mr. Bigbrain, it still remains that none of us wishes to place his government, his business, his liberty, or life itself, in the hands of a single individual, no matter how noble or wise.

The plain truth of the matter is that when the chips are down on a complex issue, we run to the shelter of multiple judgment. This is not time to summon the discoverer, or the inventor, or the lone engineer, or the lone wolves whatever their specialty in art or science. This job is for a group of men, perhaps less equipped to compete with the ultra-specialists in their chosen fields, but combining a working knowledge of the matter at hand and the ability to place the subject in the broader framework of human experience and aspirations. So it seems that when we have a problem too complex for individual decision, too important to be exposed to the fallibility of the most erudite expert, too comprehensive to be encompassed by the wisest of men, we turn to the much-abused committee, an organism that must of necessity play for percentages, not for miracles; for accomplishment, not for headlines.

The fun-making at the expense of committees should continue. If committees were really useless, we would be crying, not laughing. The fact that committeemen can laugh at themselves is the best of all signs of intellectual maturity and the relaxed confidence of sincere people doing the best job of which they are capable. They experience a restful security in the knowledge that their function is unique and matchless.

Then, there is the personal angle. To be chosen for committee work, out of the many that could be selected, is a rewarding occurrence in professional life; a badge of honor, so to speak, in one's field of competence, and identification as a man whose opinions are freely given but not for sale. It stamps the individual with the sign of integrity, of the courage to speak though what he says may win no popularity contests; and finally, a person who considers compromise a nice, clean word that symbolizes man's humanity to man through the capacity for submerging his selfish interests for the over-all good.

Animals do not form committees; this is a privilege granted by the Creator solely to man as the supreme reflection of His image and likeness. To man alone goes the sanction of combining his intellect with other men, to accomplish intellectually and spiritually what cannot be accomplished alone, to unify when singleness fails, and to adjust his individual desires to the broad mural of common welfare.

And animals don't laugh!

1960 Nuclear Congress Papers Available

COPIES OF MOST of the papers presented at the 1960 Nuclear Congress held in New York, April 3–8, 1960, are still available. For those who found it impossible to attend the Congress, and who wish to obtain printed copies of papers, provision has been made for mail order distribution. This service is in line with the first objective of the Congress, "To provide free exchange of knowledge in the subject area between engineers and scientists and the industry which is dependent upon such information."

ASTM was one of 28 engineering and scientific organizations supporting the 1960 Nuclear Congress. Copies of three of the four papers from the ASTM-sponsored session are still available. These are:

Paper 41. ASME Committee on Nuclear Power of the Boiler and Pressure Vessel—Nuclear Standards—*D. A. Rogers.*

Paper 42. Nuclear Standards—American Standards Association's Materials Task Force, Nuclear Advisory Committee—*J. A. Klapper.*

Paper 62. Nuclear Standards—American Society for Testing Materials—*G. D. Calkins.*

A list of the remaining 40-odd papers available, as well as copies of the papers themselves, are available from the 1960 Nuclear Congress, 29 W. 39th St., New York 18, N. Y. Papers may be ordered by number, or as a complete set. The price is 50 cents per paper, or $20 for the set.

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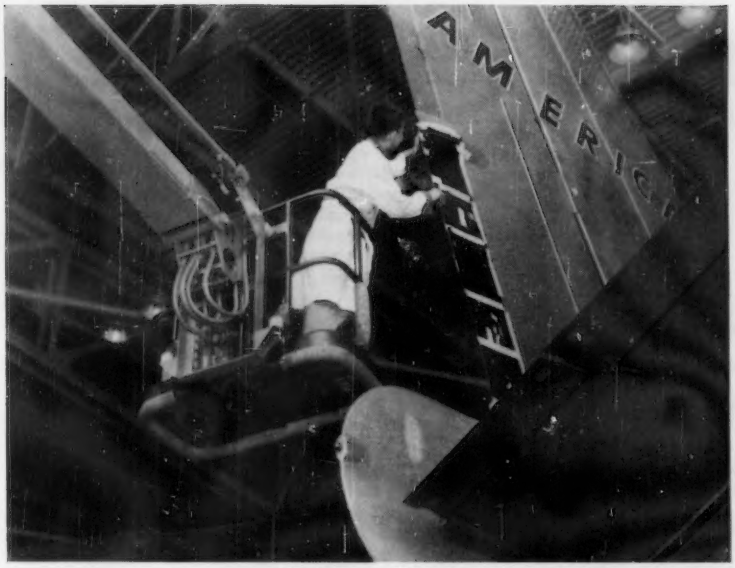

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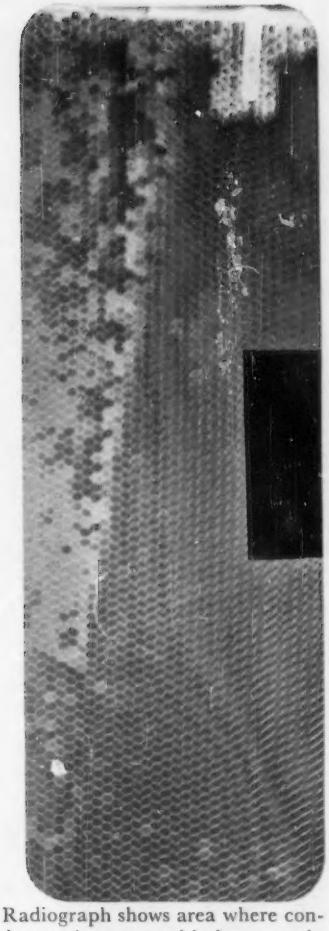

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Copies of these books are not available through ASTM; all inquiries concerning them should be addressed to the publisher.

Studies in Practical Pyrometry (in French)

R. Alegre, M. Ancey, R. Kissel, R. Lacroix, G. Monnot, A. Mouttet, M. Riviere, and G. Urbain; Editions Eyrolles, 61 Boulevard St.-Germain, Paris (1959); 231 pp.; Illus.; 3440 francs (approx. $7).

Adapted from publisher's description.

THIS BOOK was compiled to fill the need for a book in the French language on the various problems encountered in the measurement of temperature. The result of a collaboration of specialists, the book is intended for practical orientation and application.

The first chapter reviews the various techniques of pyrometry, then discusses the applications of these techniques. The remainder of the book discusses in greater detail such topics as the use of thermistors with a high coefficient of variation of electrical resistance as a function of temperature; new radiation receptors (photoemissive cells with a weak discharge voltage, electron multipliers, arresting ground cells, lead sulfide photoresistant cells, etc.), which, because of their amplifying devices, make possible practical industrial apparatus with a short response time, well adapted to recording and control; and measurement of temperature in industrial flames. Research on the best operating conditions of flame furnaces has justified construction of an industrial version of the intake pyrometer. The modification presented makes possible precision measurement of flame, vapor, etc.

Developmental work on combustion, especially in rocket chambers, statoreactors, and turboreactors, has necessitated the study of flame pyrometric methods in which the dynamic performance is in agreement with the speed of the phenomena (some procedures described have a response time lower than 10^{-5} sec).

The theory and technique of the apparatuses are explained; examples and results obtained in specific cases are given.

Materials and Processes of Electron Devices

Max Knoll; Springer-Verlag (1959); 484 pp.; DM 66 (Approx. $15.70).

Reviewed by F. J. Biondi, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

THIS NEW volume in the field of the technology of the materials and processes used to fabricate electron tubes is designed as a source of information for people interested in the design of tubes. There have been very few really good texts—as a matter of fact, texts of any quality—in this field. The industry has been a rapidly moving one; and while much is published on the electrical behavior of the devices, relatively little has been published concerning the technology of fabrication. This volume begins by discussing the basic properties of materials and techniques for measuring these properties and then proceeds to discuss, as individual metals, first the high-melting and then the base metals and their alloys. Insulators and a passing reference to semiconductors follows, then a review of gases and outgassing procedures. The next section deals with techniques for joining, shaping, and treating the surfaces of metallic tube elements, including the handling of glass. The book concludes with a discussion of exhaust and gettering processes. The volume in essence is an annotated bibliography. The book actually contains 2300 references to the literature. Regrettably, but understandably, the book does not contain really recent practices and information. For example, the chapter on the purification of gases contains techniques largely abandoned more than five years ago. The chapter on the preparation of surfaces almost completely ignores recent technology aimed at the control of surface contaminants and makes no reference to the use of modern washing procedures, including the widely used deionized-water and ultrasonic techniques. For the well-informed and experienced tube designer, this book will provide little in the way of new information. It does provide, however, in one place, a collection of useful data for reference purposes. For the newcomer in the field it provides background information.

(*Continued on p. 66*)

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BOOKSHELF

(*Continued from p. 64*)

Zinc: The Science and Technology of the Metal, Its Alloys and Compounds

Edited by C. H. Mathewson, Am. Chemical Soc. Monograph, Ser. No. 142, Reinhold Publishing Corp., New York (1959); 721 pp.; Illus.; $19.50.

Reviewed by B. W. Gonser, Battelle Memorial Institute, Columbus, Ohio.

THIS IS a comprehensive book of broad coverage, written by a well-selected group of specialists. The 52 contributors represent an impressive cross-section of the zinc production and usage fields. Several are from Canada and England.

Frequently, a book of this nature in which individual chapters or sections of chapters are written by different people shows overlapping of information, gaps in coverage, and general disjointedness. That is not a prominent fault here. Dr. Mathewson and the cooperating American Zinc Institute Committee have done an excellent job of proper organization of subject matter and editing to minimize the inevitable changes in style of writing and specialized viewpoints of the many authors. In fact, breaking up many of the chapters into sections for specific coverage by an authority in that field makes it much easier for a reader to locate the information he particularly desires. After all, this is a reference book, not a novel.

Starting with an interesting account of the historical background of zinc, the general economics and statistics of the industry are presented, and a good 30-page chapter covers the geology of zinc deposits. The chemistry and physics of zinc technology, as given in a chapter by Schumann and Schadler, treats particularly the physical chemistry of extractive zinc metallurgy rather than discussing zinc compounds. These are covered in a later chapter on industrial zinc oxide, zinc sulfide, and other zinc compounds. Ore concentration and metallurgical extraction are given detailed attention in some 230 pages. This includes an excellent section on zinc production in a blast furnace (practice at Avonmouth, England), as well as sections on the more common retort, electrolytic, electrothermic, and slag extraction processes, and on scrap recovery, melting, and casting. Likewise, a chapter on "The Processing and Uses of Metallic Zinc and Zinc-Base Alloys" gives detailed treatment to zinc physical metallurgy. This, with a discussion of zinc as an alloying agent by the editor, takes 240 pages. It is well done. Zinc coating, with emphasis on hot-dip galvanizing of various products, is particularly well covered by 14 specialists. Timely sections on continuous-line galvanizing of sheet by the Sendzimir, Cook-Norteman, and U. S. Steel procedures are noteworthy.

Adequate attention is given to the manufacture of zinc oxide by various means and to the use of zinc in agriculture and wood preservation. An interesting and informative chapter not usually found in a book on zinc is "The Biological Significance of Zinc." Another uncommon article of timely, as well as historic interest, is a chapter by T. D. Jones on the use of zinc to recover other metals, including the recovery of gold, silver, and platinum metals by zinc precipitation from lead in ramifications of the Parkes process. More recent applications include recovery of thallium and cadmium and the production of tin-lead solder by reaction of tin tetrachloride and a lead-zinc alloy from lead refining. Zinc in brass and zinc in general corrosion prevention have been purposely omitted since they are covered adequately in other books of the ACS Monograph series. However, zinc alone, as rolled zinc, and zinc anodes for cathodic protection are subjects of special sections.

Throughout the book references are given, and the subject material seems to be well indexed. This is a good book that brings zinc technology well up to date and should be an excellent, useful addition to the bookshelves of anyone interested in zinc in any form.

Properties of Matter

F. C. Champion and N. Davy; 3rd Ed., Philosophical Library, New York (1959); 334 pp.; Illus.; $10.

Reviewed by Arthur Schach, National Bureau of Standards, Washington, D. C.

DESPITE THE lapse of more than two decades since the appearance of its first edition (published by Blackie and Son, Ltd., Glasgow, 1937), Champion and Davy's intermediate-level undergraduate text remains essentially unchanged in basic content. To be sure, as the authors remark, there has been a "gradual orientation of the subject from a largely phenomenological treatment to atomic interpretations"; but this has been achieved by relatively brief additions and deletions that leave the core of the book untouched. Still present, in particular, is the original emphasis on the theory underlying the principal methods of measuring the properties that are treated. Indeed, the possible usefulness of the book for readers of the ASTM BULLETIN lies mainly in the introduction it provides to such methods of measurement.

The authors note that "the subjects comprising the Properties of Matter form an ill-defined group" from which they "have attempted to treat selected topics adequately rather than to cover a very wide field." First, however, they present a chapter on units and measurements that contains a notably sensible and compact discussion of the difficult subject of dimensional analysis; while the final chapter summarizes with equal brevity some well-known results of the

(*Continued on p. 68*)

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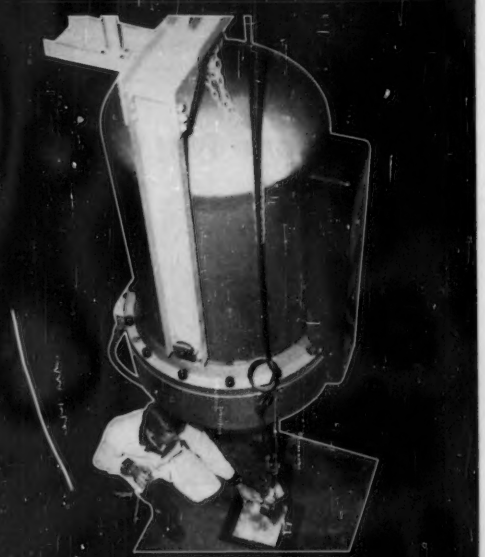

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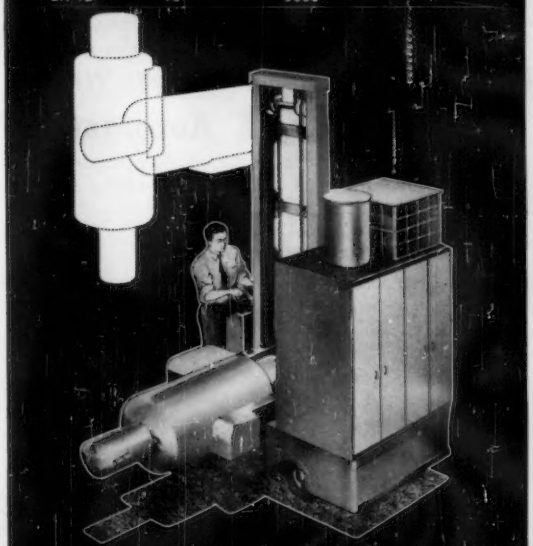

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(*Continued from p. 66*)

theory of errors and illustrates the use of the method of least squares in determining a "most reliable" value of Planck's constant (in the manner of Bond and Birge). Between these opening and closing chapters there are relatively extended treatments of gravitational field measurements, elasticity, capillarity, kinetic theory, osmotic pressure, and viscosity; with somewhat shorter chapters on compressibility of liquids and solids, seismic waves, surface films, and diffusion. In these areas, attention is given to methods for determining the acceleration of gravity and its variation with time and position, the constant of gravitation, elastic constants, high and low pressures, bulk modulus, seismic parameters (with applications to geophysical prospecting), surface tension, surface pressures and areas, molecular sizes and numbers (from kinetic theory), osmotic pressure, diffusivity of a solute in a liquid, and viscosity of liquids and gases.

Readers are supposed to have a fairly solid preparation in general physics, particularly in mechanics; and in a number of places results are assumed from advanced undergraduate thermodynamics. A senior undergraduate engineering or physics major would find the mathematics only mildly difficult at worst; where mathematics of greater difficulty than this would be required, the authors content themselves with a summary of results to round out the presentation.

The general quality of the presentation is competent, and in a number of places attests to considerable pedagogical skill on the part of the authors. It happens that in this general field the reader now has at his disposal a number of quite excellent texts; and in the face of such strong competition the present work might easily be overlooked. However, those who are looking for a first introduction to the methods of measurement with which it deals will find that it has much to offer.

Physical Methods of Investigating Textiles

Edited by R. Meredith and J. W. S. Hearle; Textile Book Publishers, Inc.; 411 pp.; Illus.; $13.

Reviewed by N. J. Abbott, Fabric Research Laboratories, Inc., Dedham, Mass.

THIS BOOK is an edited record of a course of lectures held in 1957 at the Manchester College of Science and Technology. It very usefully fills a gap in the bookshelf of every textile laboratory, and the editors are to be thanked for permitting all of us to benefit from these lectures, which provide an excellent compendium of information about techniques.

The chapter headings adequately describe the comprehensive nature of the book. They are: X-ray Techniques; Infrared Spectroscopy; Electron Microscopy; Optical Microscopy; Fiber Dimensions; Density, Moisture, and Swelling; Yarn and Fabric Structure; Mechanical Properties of Fibers and Yarns; Some Mechanical Properties of Fabrics; Transmission of Heat, Moisture, and Air; Frictional Behavior of Textiles; Optical Properties; Electrical Properties; and Application of Nuclear Physics. A detailed subject index is provided, as well as an author index, a rather unusual but most welcome addition to a textbook. The names of the twelve chapter authors will, for the most part, be well known to anyone conversant with the textile literature.

Whole books could be written about most of these chapters, and, in fact, have been in many cases. However, the editors have solved the problem of condensation of information very satisfactorily. The book is aimed strictly at discussing techniques, not results, except in sufficient detail to illustrate the usefulness of the technique. Each chapter is followed by an extensive bibliography listing both textbooks and papers where more detailed information can be found. Needless to say, all the chapter authors are not equally successful in coping with the difficult task of selection of material and succinct clarity of writing. The reader may often wonder about the exclusion of a technique which he himself has found useful.

(*Continued on next page*)

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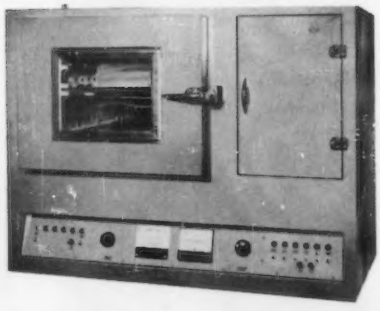

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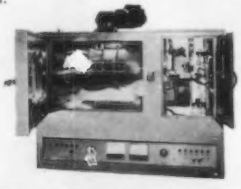

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One omission which seemed particularly unfortunate to this reviewer concerned the discussion of the density gradient column in Chapter 6. This is a technique which almost any textile laboratory would find useful; therefore it is a pity that the delightfully elegant method of preparing such a column, which is described in ASTM Method D 1505 - 57 T, was not mentioned.

However, it would be a mistake to imply that such omissions are serious. This is a book to whet the appetite, not to satisfy it. It can be recommended highly to anyone interested in the technical aspects of textile science. Those chapters which deal with subjects that may be familiar to the reader are interesting because they provide a well-written review. Those topics that are not familiar to the reader will open his eyes to the possibility of using new techniques that may prove of great value to him. It is only the most unimaginative of experimenters who will not derive benefit from reading this excellent book.

Elements of Materials Science

Lawrence H. Van Vlack, Addison-Wesley Publishing Co., Inc., Reading, Mass. (1959); 528 pp.; illus.; $8.75.

Reviewed by A. T. McPherson, National Bureau of Standards, Washington, D. C.

THIS TEXTBOOK represents a new approach to the study of engineering materials based on principles that relate the properties and behavior of materials to their structure and constitution. Instead of the former empirical treatment of many individual materials it is now possible to provide a systematic knowledge of principles that will permit the engineer to understand better the characteristics of present materials and to anticipate, at least qualitatively, the behavior of materials that may be developed in the future.

Chapter 1 of the book is an introduction to orient the student and acquaint him with engineering terminology. Chapters 2 through 10 deal with the internal structures of materials and the dependence of properties upon these structures. The sequence followed—from atoms, to crystals, to phases, to microstructures, and finally to macrostructures—is logical, since the grosser structures and properties depend upon the finer. Structures are dealt with not in the abstract, but in terms of metals and alloys, ceramic materials, organic materials, and polymers. A great deal of information about engineering materials is presented in a manner that can be understood and appreciated through the relation to the underlying principles.

Chapters 11 through 15, devoted to the behavior of materials in service, treat the following subjects: stability under service stresses; corrosion; thermal, electric, and magnetic behavior;

(*Continued on p. 70*)

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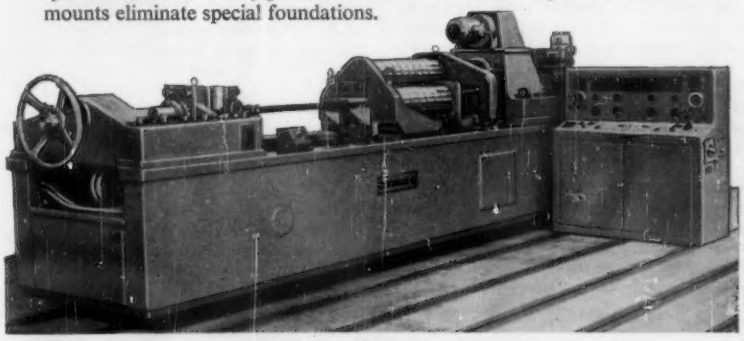

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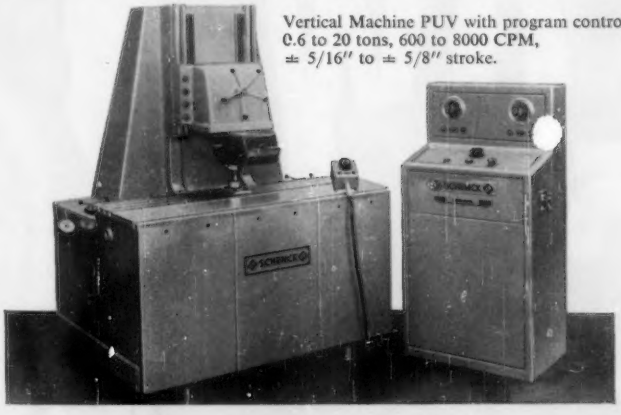

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(*Continued from p. 69*)

and the effects of irradiation. Here, as in the earlier chapters, engineering behavior is related to basic principles, and many of the concepts of modern chemistry and physics are presented concisely, in simple language without rigorous mathematical derivations.

Each chapter is provided with problems and references; the latter are carefully annotated as to the scope and level of presentation. Ten appendices occupying 70 pages add to the value of the book for reference, since they include a comprehensive glossary, tables of properties, phase diagrams, organic structures, and other pertinent data.

All persons concerned with engineering materials will find this book stimulating reading and useful for reference. It will be especially valuable to the engineer who has had formal training in only one or two materials and finds it necessary in his job to extend his knowledge to a wider range of materials and to keep abreast with the application of recent advances in science to engineering problems. The metallurgist, the ceramist, the polymer chemist, the electronic scientist, and the production engineer will each find in the book a fresh approach to his own field and a source of knowledge and new ideas drawn from fields other than its own.

Radioisotopes for Industry

Robert S. Rochlin and Warner W. Schultz; Reinhold Publishing Corp. (1959); 190 pp.; $4.25.

Reviewed by H. J. Stremba, ASTM Staff.

THE USE of radioisotopes for process control or research has cut costs and solved some baffling problems in almost every industry where it has been tried. This book shows exactly how it is done. It describes many proved uses for radioisotopes including thickness measurements, detection of wear on moving parts, fluid flow, corrosion studies, and a host of other schemes that have paid off handsomely in dollar savings.

Consider, for example, how radioisotopes were used in a hydroelectric plant to measure the erosion caused by water impinging on the blades of huge turbines. Spots were painted on blades with radioactive paint. By monitoring the rate at which the paint was eroded, engineers were able to measure relative erosion as a function of turbine load and speed. It was discovered that just beyond the point of maximum turbine efficiency the wear rate increased sharply. This indicated careful adherence to operating specifications was essential to prevent excessive wear.

This book, written for executives and plant engineers, assumes no prior knowledge of radioactivity and nuclear science. Its purpose is to introduce the reader to the benefits and over-all importance of radioisotopes.

It illustrates the application of these powerful and versatile tools with a minimum of unfamiliar jargon or highly technical discussion. A wealth of technical material is, however, included in the appendices and if the reader should discover an application meeting his needs, the extensive bibliography will guide him to the technical information on the specific subject.

Although this is not a textbook, it will be useful to engineering students as well as plant engineers in keeping them abreast of our expanding technology.

Principles of Pavement Design

E. J. Yoder; John Wiley & Sons, Inc. (1959); 569 pp.; illus; $13.25.

Reviewed by L. C. Gilbert, ASTM Staff.

ALTHOUGH pavement design procedures vary according to the specific application, there are basic principles that apply to all airfield and highway pavements, both flexible and rigid. The author has devoted a considerable portion of his book to setting forth these basic factors in pavement design.

Properties of pavement components and tests for them are outlined. The evaluation of subbase materials, principally soil and soil stabilization, is given. The text then leads into actual design of both flexible and rigid pavements and closes with pavement evaluation and methods of strengthening existing pavements.

(*Continued on p. 78*)

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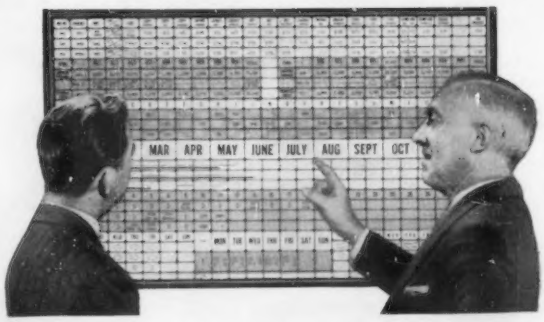

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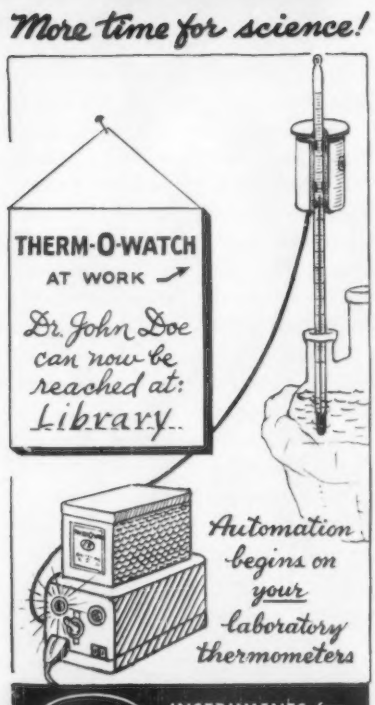
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June 5–8—**American Gear Manufacturers Assn.,** Annual Meeting, The Homestead, Hot Springs, Va.

June 5–8—**Special Libraries Assn.,** 51st Annual Convention, Cleveland, Ohio.

June 5–9—**Forest Products Research Society,** 14th National Meeting, Queen Elizabeth Hotel, Montreal, Canada.

June 5–9—**American Society of Mechanical Engineers,** Summer Annual Meeting and Aviation Conference, Statler-Hilton Hotel, Dallas, Tex.

June 5–10—**Society of Automotive Engineers,** Summer Meeting, Edgewater Beach Hotel, Chicago, Ill.

June 6–8—**Edison Electric Inst.,** Annual Meeting, Hotel Traymore, Atlantic City, N. J.

June 8–11—**National Society of Professional Engineers,** Annual Meeting, Statler Hotel, Boston, Mass.

June 9–10—Hudson-Mohawk Section, **American Institute of Mining, Metallurgical, and Petroleum Engineers,** Columbium Metallurgy Symposium, Hotel Sagamore, Bolton Landing, Lake George, N. Y.

June 12–16—American Nuclear Society, 6th Annual Meeting, Chicago, Ill.

June 13–15—**The Chemical Institute of Canada,** Annual Conference, Chateau Laurier, Ottawa, Ont.

June 13–15—**American Society of Heating, Refrigerating, and Air-Conditioning Engineers,** Annual Meeting, Royal York Hotel, Vancouver, B. C.

June 13–15—International Conference on Powder Metallurgy (**Metal Powder Industries Federation and the Metallurgical Society of AIME**), Hotel Biltmore, New York, N. Y.

June 12–15—**American Society of Agricultural Engineers,** Annual Meeting, Ohio State University, Columbus, Ohio.

June 19–22—**American Institute of Chemical Engineers and Instituto Mexican de Ingenieros Quimicos,** Joint Meeting, Del Prado, Mexico City.

June 20–24—**The American Society for Engineering Education,** Annual Meeting, Purdue University, Lafayette, Ind.

June 20–24—**American Society of Civil Engineers,** Reno, Nev.

June 20–24—**American Institute of Electrical Engineers,** Summer Meeting, Atlantic City, N. J.

June 27–July 7—**First International Congress for Automatic Control,** Moscow, USSR.

June 27–29—**Institute of Radio Engineers,** National Conference on Military Electronics, Sheraton-Park Hotel, Washington, D. C.

June 27–30—**Institute of the Aeronautical Sciences,** National Summer Meeting, Ambassador Hotel, Los Angeles, Calif.

June 27–July 1—**6th Congress of the International Association for Bridge and Structural Engineering,** Stockholm, Sweden

July 19–22—**American Institute of Architects,** Convention, Denver, Colo.

July 24–28—**American Electroplaters' Society,** Annual Convention, Statler Hotel, Los Angeles, Calif.

OTS Research Reports

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USSR Literature on Air Pollution and Related Occupational Diseases, Vol. 1, OTS 60–21049, $3.50.

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(*Continued on p. 84*)

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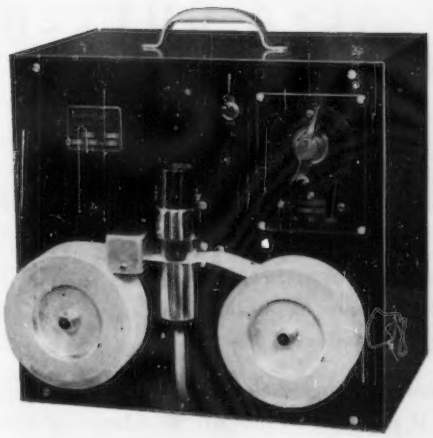

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(*Continued on next page*)

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Cotter, Anne Marie, specification engineer, Scientific Design Co., 2 Park Ave., New York, N. Y. For mail: 325 E. 206th St., New York 67, N. Y. [A]

Cubitt, Robert B., chemical engineer, Engineering Materials Section, Research and Development, Colgate-Palmolive Co., 105 Hudson St., Jersey City 2, N. J. For mail: 87 Clifton Pl., Jersey City 4, N. J. [A]

DeVito, Carmin J., soils and foundation engineer, Edwards & Kelcey, 3 William St., Newark 2, N. J.

Fitzgerald, Thomas W., engineer, International Telephone and Telegraph Corp., Components Div., Box 412, Clifton, N. J [A]

Freedman, N. S., manager, Chemical and Physical Laboratory, RCA Victor Co., Tube Div., 415 S. Fifth St., Harrison, N. J.

Kelsey, Chester Creed, supervisory engineer, Sidney B. Bowne & Son, Box 109, Mineola, N. Y. For mail: 2379 Elk Ct., North Bellmore, N. Y.

Landers, F. S., chief project engineer, Lily-Tulip Cup Corp., 117th St. and 15th Ave., College Point 56, N. Y.

Lominska, Clemense A., manager, Paint Testing Station, National Lead Co., Box 391, Sayville, N. Y.

Malchman, Marian C., librarian, Fairchild Astrionics Div., Fairchild Engine and Airplane Corp., Wyandanch, L. I., N. Y.

Niven, Thomas A., industrial economist, 35 Wilson Dr., Berkeley Heights, N. J.

Preusser, Robert H., 1927 Cornelia St., Brooklyn 27, N. Y. [A]

Schumann, O. Douglas, marketing group manager, Fiber Dept., Air Reduction Chemical Co., 150 E. 42nd St., New York 17, N. Y.

Wening, Richard Edgar, associate editor, *Rubber World*, 630 Third Ave., New York 17, N. Y. [A]

Witkiewicz, Joseph J., product development engineer, Chemplast, Inc., 3 Central Ave., East Newark, N. J.

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Tompkins, James F., president, Industrial Kanigen Corp., 1421 Park Ave., Emeryville, Calif.

Volberg, Fred J., manager, Industrial Dept., Plant Asbestos Co., 1300 64th St., Emeryville 8, Calif.

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Abrams, Frank J., Jr., electronics student, U. S. Department of the Air Force, Kessler AFB, Miss. For mail: 4366 Olney, Indianapolis, Ind. [A]

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Dunlap, William N., Jr., president, Sandoe Laboratories, 73 Rochelle Ave., Philadelphia 28, Pa.

Hegmegee, Paul E., Jr., foundry manager, Taylor-Wharton Co., High Bridge, N. J.

Sorenson, Gordon Robert, engineer in charge of transducer development, The Budd Co., Instruments Div., Phoenixville, Pa. For mail: 277 Lincoln Rd., King of Prussia, Pa.

Taylor, Thomas J., manager of research, R. C. Remmey Son Co., Hedley St. and Delware River, Philadelphia 37, Pa.

VanKuren, R. C., graduate student, Lehigh University, Bethlehem, Pa. For mail: R. D. 1, Durn's Park, Center Valley, Pa. [A]

Woodings, E. J., manager, Chemical and Metallurgical Laboratories, Thompson Ramo Wooldridge, Inc., 1400 N. Cameron St., Harrisburg, Pa.

Continued on p. 76)

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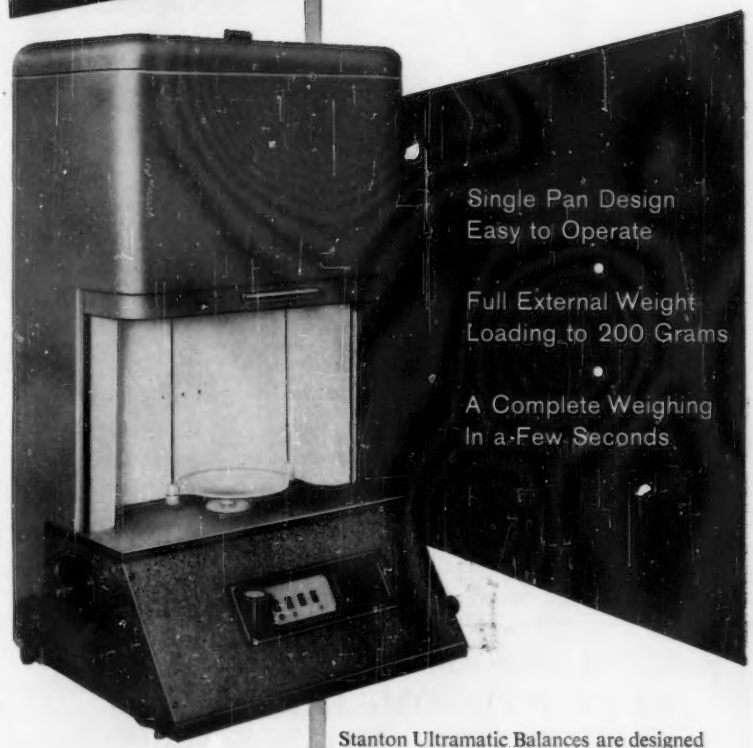

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Lange, Robert A., engineer, Westinghouse Electric Corp., Bettis Atomic Power Laboratory, Box 1468, Pittsburgh 30, Pa. For mail: 136 Elmwood Dr., Glenshaw, Pa.

Reed, K. Duane, chief chemist, The Pennsylvania Railroad Co., Test Dept., Altoona, Pa.

St. Louis District

Baker, Richard S., Jr., chief engineer, Progress Manufacturing Co., Inc., 219 N. Walnut, Arthur, Ill [A]

Hazard, Stuart G., partner, Servis, VanDoren & Hazard, Box 719, Topeka, Kans.

Heter, M. W., chief mechanical and structural engineer, Kansas City Power and Light Co., Box 679, Kansas City 41, Mo.

Southeast District

Brown, Robert E., metallurgist, Alabama Metallurgical Corp., Selma, Ala. [A]

Southern California District

Columbia Wax Co., W. F. Haverkamp, chairman of the board; technical director, 530 Riverdale Dr., Glendale 4, Calif.

Chapman, James W., engineer trainee, U. S. Corps of Engineers, 751 Figueroa St., Los Angeles 17, Calif. For mail: 228 South Ave., 50, Los Angeles 42, Calif. [A]

Daugherty, Charles F., owner, South Gate Engineering and Fabricating Co., 9220 Atlantic Ave., South Gate, Calif.

Dayton, John G., chief chemist, Wilshire Oil Company of California, Box 2487, Santa Fe Springs, Calif.

Fordham, Paul A., research technician, Materials Engineering Section, Dept. 322, Aerojet-General Corp., 6352 N. Irwindale Rd., Azusa, Calif. For mail: 13618 Benfield, Norwalk, Calif.

Kautz, Donald, director, X-ray laboratory, Ferro-Spec Laboratories, Inc., 4112 S. Main St., Los Angeles 37, Calif.

Murray, John S., executive vice-president, Standard Felt Co., 29–115 S. Palm Ave., Alhambra, Calif.

Rubin, Martin A., intermediate scientist, Litton Industries, 11728 Olympic Blvd., W. Los Angeles, Calif. For mail: 11803 Goshen Ave., No. 3, Los Angeles 49, Calif. [A]

Striepens, Aloys H., research engineer, North American Aviation, Inc., Missile Div., 12214 Lakewood Blvd., Downey, Calif. For mail: 12624 Lakewood Blvd., Apt. 5, Downey, Calif. [A]

Whitman, John E., vice-president, Hunt Process Co., Inc., 7012 Stanford Ave., Los Angeles 1, Calif.

Southwest District

Brandau, Edna Prechel, member of research team, Texas Woman's University, Denton, Tex. For mail: 1917 Bell Ave., Denton, Tex.

Denney, Kenneth, aeronautical engineer, U. S. Department of the Air Force, Tinker AFB (OCAMA), Oklahoma City, Okla. For mail: 528 Showalter Dr., Midwest City, Okla. [A]

Finster, K. C., laboratory supervisor, The Dow Chemical Co., B-2008 Bldg., Freeport, Tex.

Mahan, Norman R., 1303 S. Louisville, Tulsa 12, Okla. [A]

Roesler, Gary Albert, district engineer, Moretrench Corp., 315 W. 25th St., Houston 8, Tex. For mail: Box 7397, Houston 8, Tex. [A]

Sheppard, Lyle R., senior engineer, technical service, Shell Pipe Line Corp., Shell Bldg., Houston 1, Tex. For mail: 6522 Mercer St., Houston 5, Tex.

Trenholme, L. B., Union Carbide Chemicals Co., Box 471, Texas City, Tex.

Willis, Arthur C., senior test engineer, Temco Aircraft Corp., Box 6191, Dallas 22, Tex. For mail: 1112-D Sangamon Dr., Dallas 18, Tex.

Washington (D. C.) District

Cone Mills Corp., Clyde T. Canter, head, Technical Section, 1112 Maple St., Greensboro, N. C.

Lynch, R. W., sales manager, Southern Materials Co., Inc., Box 420, Norfolk, Va.

Marxmann, George H., highway research engineer, Bureau of Public Roads, Division of Physical Research, Washington 25, D. C.

Tate, Douglas R., physicist, National Bureau of Standards, Washington 25, D. C.

Taylor, William H., wool laboratory supervisor, Pacific Mills, Clarksville, Va.

Thompson, Charles L., research associate, National Bureau of Standards, Rm. 307, Bldg. 6, Washington 25, D. C.

Western New York–Ontario District

Harbison-Carborundum Corp., William A. Miller, supervisor, glass refractories research, Box 157, Falconer, N. Y.

Carmichael, J. L., chief chemist, St. Lawrence Cement Co., Box 520, Clarkson, Canada. [A]

Forbes, Donald W. A., director of research, Hamilton Porcelains, Ltd., Box 594, Brantford, Ont., Canada.

Kayser, Emil J., laboratory director, Schlegel Manufacturing Co., 1555 Jefferson Rd., Rochester 23, N. Y. For mail: 1763 Empire Blvd., Webster, N. Y.

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Barnett, Steele, product development manager, Boise Cascade Corp., Box 200, Boise, Idaho.

Pearl Harbor Naval Shipyard, commander (Code 375), Navy No. 128, FPO, San Francisco, Calif.

Schwietz, Lawrence E., chief chemist, McCollister Grease and Oil Corp., 20th and Williams Sts., Omaha 2, Nebr. For mail: 6804 Minne Lusa Blvd., Omaha 12, Nebr.

Swanson, Erwin W., materials engineer, U. S. Corps of Engineers, Mountain Home

(*Continued on p. 78*)

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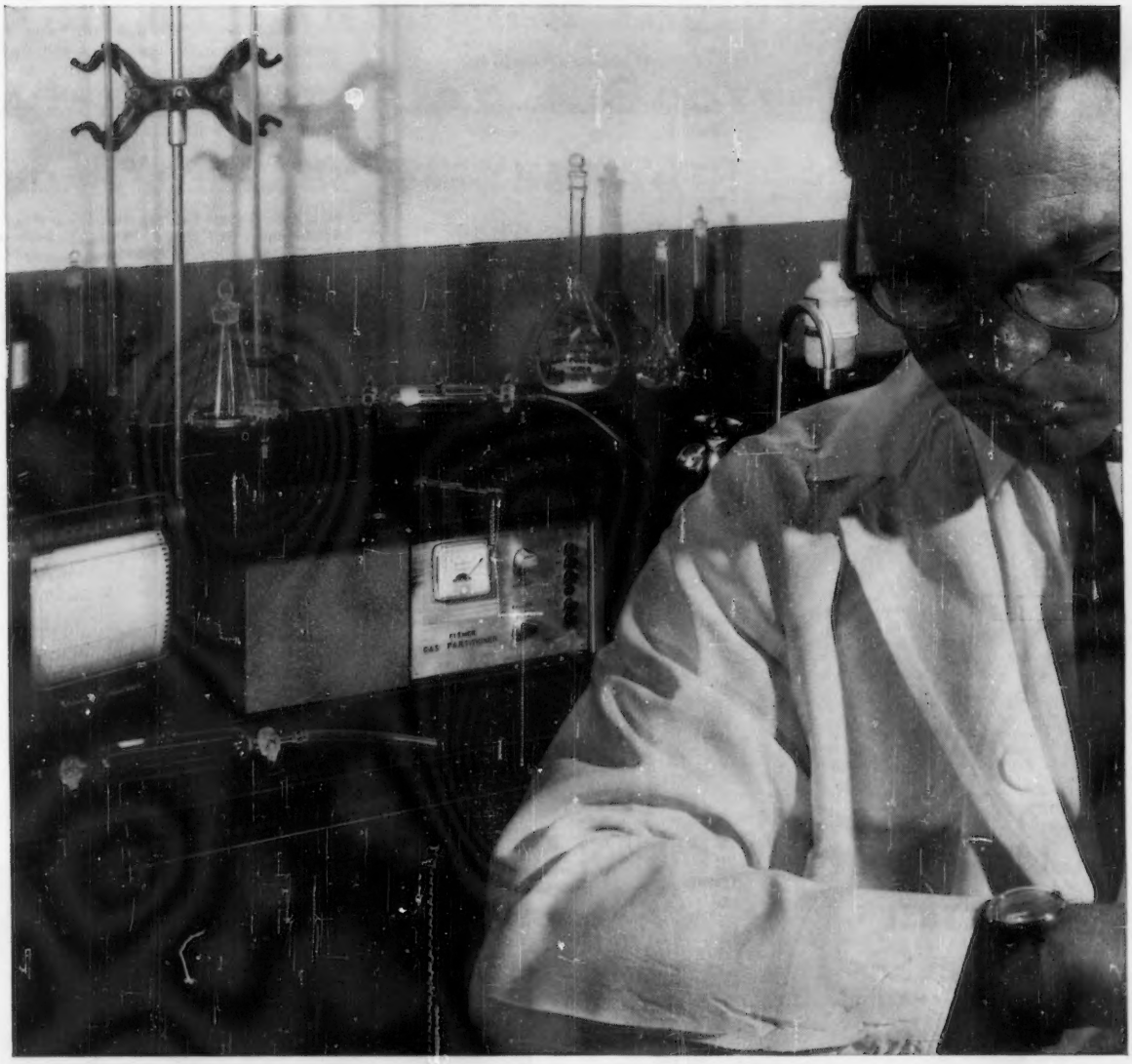

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Atomic Energy of Canada, Ltd., E. C. W. Perryman, assistant director, Chemical and Metallurgical Div., Chalk River, Ont., Canada.

Barzaghi, Luciano, assistant director, Ceramica Sao Caetano, S. A., Sao Paulo, Brazil. For mail: Caixa Postal 278, Sao Paulo, Brazil.

Dorais, Marcel, chief engineer, Michaud & Simard, Inc., 575 Arago, W., Quebec, P. Q., Canada. For mail: 2381 Laurier Blvd., Sillery, P. Q., Canada.

Faculty of Technology and Engineering, Maharaja Sayajirao, University of Baroda, Baroda, Bombay State, India.

Heng, Low Yang, officer in charge, soils laboratory, Public Works Dept., Brunei, British Borneo.

Highways Research Station, The Director, Madras 25, India.

Kofoed, C. A., quality control manager, Danfoss, Nordborg, Denmark. For mail: Th. Brorsensvej 18, Nordborg, Denmark.

Lira, Avila, Jose Luis, chemical engineer, Cementos del Pacifico, S. A., Angel Flores 360, 3er Piso, Mazatlin, Sin., Mexico. For mail: Marmol, Sin., Mexico.

Nini, Ahmed, assistant chemist, Hasni Vanaspati Manufacturing Co., Ltd., P. O. Amin Jute Mills, Chittagong, East Pakistan.

Rioseco, Valerio, assistant superintendent, Metallurgical Dept., Compania de Acero del Pacifo S. A., Box A-C, Talcahuano, Chile.

Saint Laurent, City of, Lucien Toupin, city manager, 777 Laurentien Blvd., Saint Laurent, Montreal 9, P. Q., Canada.

Zuffa, Giuseppe, Stirling Astaldi (Mozambique), Lda., Namialo, Portuguese East Africa.

BOOKSHELF

(*Continued from p. 70*)

Progress in Non-Destructive Testing, Vol. 1

Editors: E. G. Stanford and J. H. Fearon; The Macmillan Co., New York, N. Y. (1960); 267 pp., $12.

Reviewed by J. W. Caum, ASTM Staff.

THIS IS the first of an annual series of international volumes containing critical reviews of special aspects of nondestructive testing. In these books nondestructive testing is interpreted as any type of nondestructive measurement carried out on solids, liquids, and gases to examine some aspect of their physical, chemical, or biological condition. It is no longer sufficient to reveal an actual flaw; nondestructive methods must be devised for detecting nonuniformity in properties and for assessing the effect of nonuniformity on behavior in service. In this series reports will be published to describe the progress in relating the properties of materials to each other and to the structural factors which produce them, as well as to survey the principal methods of flaw detection.

Examples of subjects in the first volume are industrial radiography, stress wave propagation in the detection of flaws by ultrasonics, electromagnetic methods of testing metals, neutron radiography, damping capacity as applied to investigation of structure of solids, thermal conductivity as a nondestructive testing technique, and the application of nuclear magnetic resonance to testing materials.

Zone Refining and Allied Techniques

N. L. Parr; George Newnes Ltd.; Tower House, Southampton St., Strand, W. C. 2, England (1960); 184 pp.; illus.; 40 shillings.

Adapted from publisher's description

THIS BOOK deals with the technique of zone refining and gives practical information on recent advances in laboratory methods and equipment.

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(*Continued on p. 94*)

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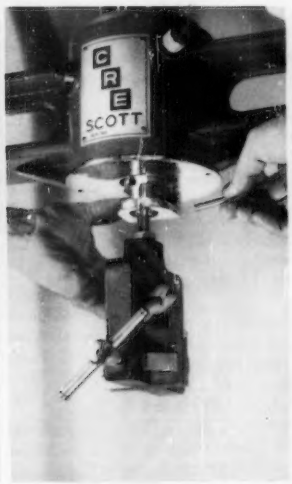

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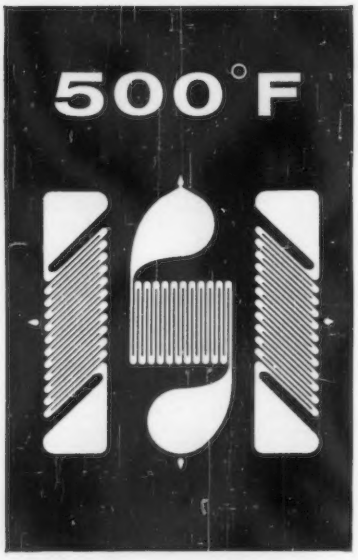

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NEWS OF MEMBERS...

News items concerning the activities of our members will be welcomed for inclusion in this column.

At its Award's Luncheon on March 16 in New York, the American Concrete Inst. conferred Honorary Memberships on **William Lerch** and **Charles H. Scholer,** both active ASTM members. Mr. Lerch, administrative assistant, Research and Development Div., Portland Cement Assn., Chicago, Ill., is a member of Committees C-9 on Concrete and Concrete Aggregates, C-12 on Mortars for Unit Masonry, C-17 on Asbestos Cement Products, C-1 on Cement, E-1 on Methods of Testing, and is currently a member of the Administrative Committee on Papers and Publications. Professor Scholer, Dept. of Applied Mechanics, Kansas State University, Road Materials Laboratory, Manhattan, Kans., has been a member of the Society since 1919 and over the years contributed to the work of Committees C-1 on Cement, C-9 on Concrete and Concrete Aggregates, D-4 on Road and Paving Materials, E-1 on Methods of Testing, E-9 on Fatigue, and the Joint Research Committee on Durability of Concrete, of which he was chairman for 7 years.

Newly elected officers of the American Concrete Inst. include several ASTM members: **J. W. Kelly,** professor, civil engineering, University of California, Berkeley, Calif., president; **Raymond C. Reese,** consulting engineer, Toledo, Ohio, vice-president; ASTM Vice-President **A. Allan Bates,** vice president, research and development, Portland Cement Assn., Chicago, Ill., member of the Board of Direction, and **Bruce E. Foster,** materials engineer, National Bureau of Standards, Washington, D. C., member of the Board of Direction.

The Mica Industry Assn., Inc., at its recent annual meeting in New York elected officers. ASTM members **Frank F. Watts,** Gillespie-Rogers-Pyatt Co., Inc., New York, N. Y., was re-elected president, and **Robert J. St. Peter,** manager, Mica Dept., Leonard J. Buck, Inc., Jersey City, N. J., was re-elected first vice-president.

Edward J. Albert, former ASTM director, and chairman of the board of directors, Thwing-Albert Instrument Co., Philadelphia, Pa., was honored by the Scientific Apparatus Makers Assn. at its Annual Meeting in Florida in March when he was presented with the SAMA Award, the apparatus industry's highest honor. Mr. Albert served as a director of ASTM from 1954 to 1957, and is active in Committees D-9 on Electrical Insulating Materials; D-6 on Paper and Paper Products; D-13 on Textile Materials; D-1 on Paint, Varnish, Lacquer, and Related Products; D-25 on Casein and Similar Protein Materials; and E-1 on Methods of Testing. He is also an active member of the Philadelphia District Council and has served as chairman of the Entertainment Committee of the Philadelphia District many times when the Society's Annual Meetings have been held in Atlantic City.

George V. Aseff, Sr., is now senior nuclear engineer, Lockheed Nuclear Products, Inc., Dawsonville, Ga. He had been research engineer, Lockheed Aircraft Corp., Marietta, Ga.

Edward F. Bittner, a member of the Society since 1950, retired March 1, 1960, as chief metallurgist, Detroit Gear Div., Borg-Warner Corp., Detroit, Mich.

John T. Blake has been elected senior vice-president and director, Simplex Wire & Cable Co., Cambridge, Mass. Previously he was vice-president and plant manager.

F. E. Bradley, superintendent, Coline Gasoline Corp., Los Angeles, Calif., retired March 31, 1960. Mr. Bradley had been a member of the Society since 1949.

Harry A. Bright, chief, Analytical Chemistry Section, National Bureau of Standards, Washington, D. C., retired February 29, 1960, after nearly 47 years of service. Since joining ASTM in 1935, Mr. Bright participated in the activities of Committees E-3 on Chemical Analysis of Metals, A-9 on Ferro-Alloys, and A-3 on Cast Iron.

O. R. Carpenter, formerly executive assistant, Babcock & Wilcox Co., Barberton, Ohio, is now assistant vice-president, Boiler Div. Manufacturing Dept.

Gerald G. Christiansen, formerly consultant, Cement Technology, San Francisco, Calif., is development engineer, Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Frank W. Davis has been appointed technical consultant, Southwest Research Inst., San Antonio, Tex. Prior to taking this position, he was with the U. S. Atomic Energy Commission, Washington, D. C.

S. J. Dickinson, technical adviser, American Smelting and Refining Co., S. Plainfield, N. J., retired recently. Dr. Dickinson represented his company's sustaining membership in the Society.

R. P. Dinsmore, vice-president in charge of research and development, Goodyear Tire & Rubber Co., Akron, Ohio, has been elected to the Board.

Ralph H. Dudley, formerly lieutenant, Air Force Ballistic Missile Div., Headquarters, Air Research & Development Command, Los Angeles, Calif., is now engineer, Special Structures Section, Ammann & Whitney, New York, N. Y.

Emil C. Evancich is president, Wire Kraft, Inc., Rolling Prairie, Ind. Previously he was manager, Wire Div., Welcraft Products Co., Inc., New Carlisle, Ind.

(*Continued on p. 82*)

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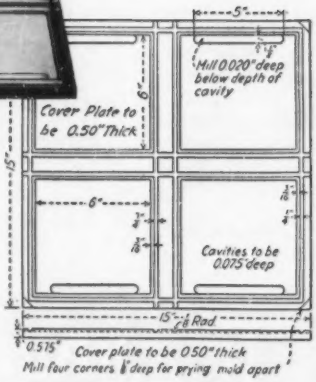
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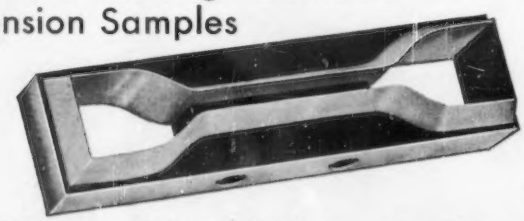

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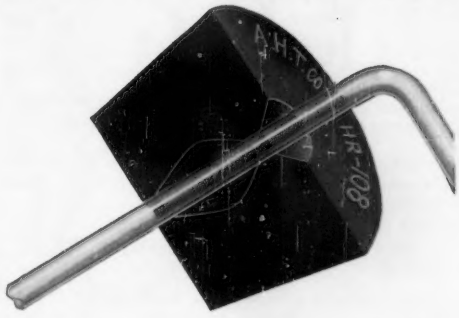

THOMAS HR-108 SAFETY STOPPERS are of bloomless, black, resilient, heat resisting composition, with low sulfur content and long life; specific gravity 1.08. Straight bore of the conventional stopper has been replaced by a fusiform bore with bevelled entrance. Internal diameter at center is approximately twice that of a 2 mm high sealing band at either end. These stoppers offer the following advantages:

Safety
Glass tubes can be easily inserted and removed, *particularly by students*, with greater safety than with straight bore. Insertion is facilitated by the bevelled entrance of the bore, and the tube slides through only the two sealing bands.

Larger Tubes
Fusiform bore permits insertion of larger tubes than is possible with straight bore. For example, tubes 6 to 11 mm can be inserted in sizes 5 to 9 incl.

Superior Composition
The stock contains *more than 70% of pure virgin gum*, possesses great elasticity, is free from surface sulfur and contains less than 0.75% free sulfur; no reclaimed rubber is used.

Heat Resistance
Temperatures *up to 110°C* do not affect shape, size or structure.

Long Life
Tests indicate useful life approximately *five times* that of common stoppers.

HR-108 Safety Stoppers are not sold by weight but, because of the specific gravity and design, include more stoppers per pound than many other brands. They are packed in cartons, each containing approximately 1 lb. of a size, for convenient shelf storage. Each size is priced individually, based on actual cost of manufacture.

For more detailed description, see pages 1066-1068 of our general catalog; current prices sent upon request

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CIRCLE 639 ON READER SERVICE CARD

NEWS OF MEMBERS

(*Continued from p. 80*)

C. T. Fletcher, research metallurgist, Braeburn Alloy Steel Corp., Braeburn, Pa., has been named chief metallurgist.

George F. Hodgson has been named director of research, Doehler-Jarvis Div., National Lead Co., Research and Development Dept., Toledo, Ohio. He was assistant chief engineer.

Alfred H. Isenberg is now with International Coatings Co., Compton, Calif. Formerly he was research manager, The Borden Chemical Co., Div. of The Borden Co., Chicago, Ill.

C. A. Kelting retired April 1, 1960, from the Consolidated Edison Company of New York, Inc., New York. He represented his company on Committee A-1 on Steel since 1936 and through the years was active in subcommittee work.

Verne C. Kennedy, Jr., executive director, University of Oklahoma, Faculty Exchange, Norman, Okla., will direct the program for the restored State Bureau of Standards. The laboratory will be on the campus of the University of Oklahoma.

Allan H. Kidder, manager, engineering research, Philadelphia Electric Co., Philadelphia, Pa., was honored by the Delaware County Section of the Pennsylvania Society of Professional Engineers by being named their "Engineer of the Year."

Augustus B. Kinzel, vice-president for research at Union Carbide, New York, N. Y., has been elected 1960 president of the Engineers Joint Council, and was appointed chairman, Division of Engineering and Industrial Research, National Academy of Sciences–National Research Council.

F. L. LaQue, vice-president and manager, Development and Research Div., The International Nickel Co., Inc., New York, N. Y., and president of ASTM, has been named to the Technical Board, The Society of Automotive Engineers.

Joseph R. Mazzola, formerly associated with Automatic Mfg. Corp., Newark, N. J., as chief engineer, is now chief production engineer, Radio Receptor Co., Inc., Brooklyn, N. Y.

H. A. Mereness, head, Physical Testing Section, Institute of Textile Technology, Charlottesville, Va., retired March 31, 1960. Mr. Mereness was an active member of Committee D-13 on Textile Materials, representing the Institute from 1947 to 1960, and also served on the council of the Washington, D. C., District from 1954 to 1956.

R. A. Miller, vice-president, Factory Standards Laboratory, Inc., Chicago, Ill., retired recently. Mr. Miller represented his company in Society membership since 1945.

Joseph G. Munisteri is associated with The Lummis Co., New York, N. Y., as construction engineer. Previously he was with the Bechtel Corp., New York, N. Y.

Louis Navias, research laboratory, General Electric Co., Schenectady, N. Y., has been given the 1960 Toledo Glass and Ceramic Award. The award, sponsored by the Northwestern Ohio Section of the American Ceramic Society, is given in recognition of scientific or engineering achievement.

David Novik is president, Westenhoff and Novick, Inc., Chicago, Ill. He had been executive vice-president, Goodkind & O'Dea, Inc., Chicago, Ill.

Donald G. Richards, formerly chief, technical staff, Hamilton Standard Div., United Aircraft Corp., Windsor Locks, Conn., is now chief engineer.

Ralph A. Schaefer, director, research and product development, The Bunting Brass & Bronze Co., Toledo, Ohio, will take office as president of the Electrochemical Society, Inc., this month.

J. S. Schaul, Jr., previously chief engineer, Alpha Plastics, Inc., Livingston, N. J., is now plastics engineer, Lock Joint Pipe Co., Wharton, N. J.

Raymond B. Seymour, formerly president, Loven Chemical Company of Calif., Newhall, Calif., is now chairman, Department of Chemistry, Sul Ross State College, Alpine, Tex.

(*Continued on p. 84*)

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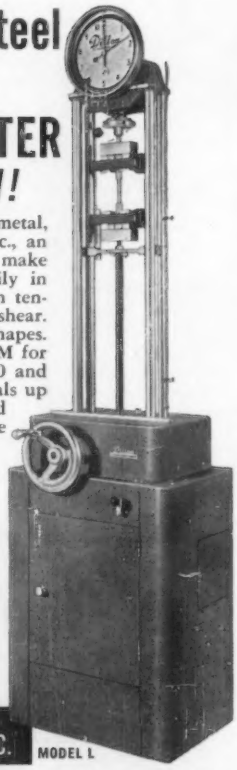

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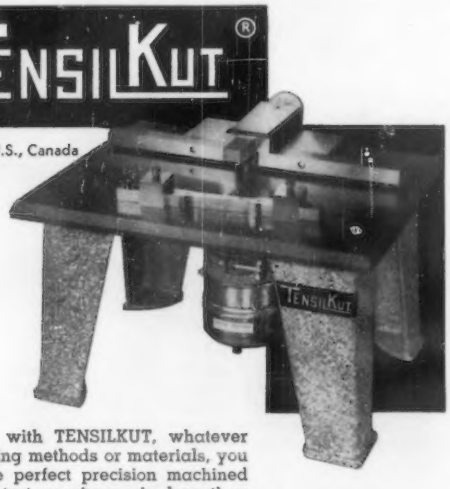

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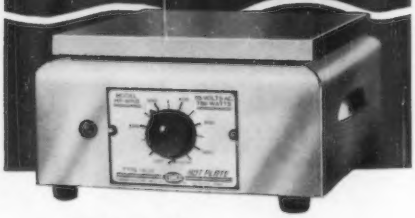

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NEWS OF MEMBERS

(*Continued from p. 82*)

Harold W. Stiegler, director of research, American Association of Textile Chemists and Colorists, Lowell Technological Inst., Lowell, Mass., retired in April. Dr. Stiegler represented the Association in Society membership and also on Committees D-13 on Textile Materials, D-12 on Soaps and Other Detergents, and the joint ASTM-AATCC Committee on Textile Test Methods.

John R. Townsend, special assistant, research and engineering, Dept. of Defense, Washington, D. C., and past president of ASTM, delivered the Edward Orton, Jr., Memorial Lecture at the 62nd Annual Meeting of The American Ceramic Society. His subject was "The Challenge to Ceramics in National Defense."

B. A. Vallerga has been appointed director of products engineering, Golden Bear Oil Co., Los Angeles, Calif. Formerly he was managing engineer, The Asphalt Inst., Berkeley, Calif.

James S. Vanick, metallurgist, The International Nickel Co., Inc., New York, N. Y., retired April 1, 1960, after 38 years of service. Mr. Vanick joined the Society in 1918 and since that time has been very active in ASTM work. He was a member of Committee A-3 on Cast Iron for 26 years, serving as chairman for 5 years; a member of Committee B-5 on Copper and Copper Alloys, Cast and Wrought, for 12 years; a member of Committee E-7 on Nondestructive Testing for 3 years; a member of Committee B-2 on Non-Ferrous Metals and Alloys for 7 years; a member of the Advisory Committee on Corrosion for 4 years; a member of the Joint Committee on Definitions of Terms Relating to Heat Treatment of Metals for 18 years, serving as chairman for 4 years; and a member of the New York District Council for 12 years.

Ralph L. Wilson, director of metallurgy, The Timken Roller Bearing Co., Canton, Ohio, received the Ohio Society of Professional Engineer's highest award at the state convention last month. Mr. Wilson was cited for his leadership in the development of quality alloy steel for the antifriction industry and for his role in doing much to raise the status of the professional engineer in industry.

Robert A. Woodall is project supervisor, Metals Div., Kelsey-Hayes Co., New Hartford, N. Y. He had been associated with Boeing Airplane Co., Renton, Wash.

DEATHS

Alfonso Abbate, materials testing engineer, Rome, Italy (January, 1960). Mr. Abbate, a new, young member of the Society, was killed in an automobile accident while working in Iran.

Oscar U. Cook, a Director of the Society from 1936 to 1938, Birmingham, Ala. (March 25, 1960). Mr. Cook joined the Society in 1913 when he was chief inspector, Carnegie Steel Co., Youngstown, Ohio. In 1918 he became associated with the Tennessee Coal, Iron and Railroad Co., Birmingham, Ala., and from 1921 until he retired in 1946 he represented his company in Society membership and also on technical committees. His was always a very familiar figure at the Annual Meetings over the years. He was very active in Committee A-1 on Steel, which committee elected him to Honorary Membership; A-5 on Corrosion of Iron and Steel; and A-3 on Cast Iron. He was a former chairman of the General Technical Committee of the AISI.

J. P. Graham, research engineer, Process and Product Development Div., Republic Steel Corp., Cleveland, Ohio (February 12, 1960). Mr. Graham represented Republic Steel on Committees D-16 on Industrial Aromatic Hydrocarbons and Related Materials and D-5 on Coal and Coke.

W. J. Parker, executive director, Slide Fastener Assn., Inc. (January, 1960). Mr. Parker represented the Association in Society membership.

R. W. Roush, chief materials engineer, Timkin-Detroit Axle Div., Rockwell-Standard Corp., Detroit, Mich. (January 29, 1960). Mr. Roush joined the Society in 1935, and served on Committee A-3 on Cast Iron for a number of years.

Stephen I. Rudo, director of research and development, Werner Textile Consultants, Larchmont, N. Y. (recently). For many years before joining the Society in 1957, Mr. Rudo represented his firm on Committee D 13 on Textile Materials.

OTS RESEARCH REPORTS

(*Continued from p. 72*)

Conference on Research in Progress on Tungsten, PB 161013, $2.50.

Bibliography on Gas-Lubricated Bearings, PB 161017, $2.50.

Heat Capacity Determination of Mineral and Synthetic Engine Oils, Lubricants, Fuels, and Hydraulic Fluids in the Temperature Range 70 to 500 F, PB 161030, $1.75.

Classification of Soviet Gas-Turbine Steels, 60-21016, 50 cents.

Corrosion of Inconel in 600-F Static Water, KAPL-2047, 75 cents.

Corrosion of Metals in Tropical Environments: Part 4—Wrought Iron, PB 151852, 50 cents.

Hydrogen-Embrittlement Susceptibility of Some Steels and Non-Ferrous Alloys, PB 151937, 75 cents.

Notch Toughness of Spheroidal Graphitic, High-Ductility, Iron Castings, PB 161120, $1.50.

Cryogenic Data Book, National Bureau of Standards Cryogenic Engineering Laboratory, PB 151837, $3.

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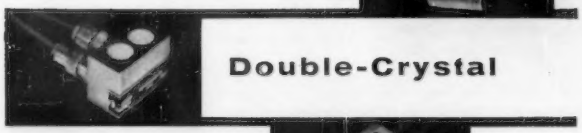

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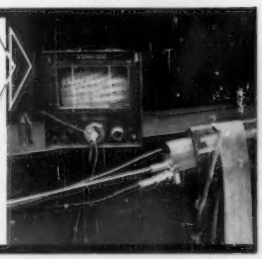

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CIRCLE 645 ON READER SERVICE CARD

NEWS NOTES ON
Laboratory Supplies and Testing Equipment

Note. This information is based on literature and statements from apparatus manufacturers and laboratory supply houses. The Society is not responsible for statements advanced in this publication.

LABORATORY ITEMS

Reference Flats—High accuracy black granite reference flats for precision measurements in tool rooms, inspection departments, and laboratories are now being made.
Acme Scientific Co. **3374**

Magnetic Amplifier—This magnetic amplifier is designed to produce a maximum power output of 3.5 w at 400 cps into a rated load of 3800 ohms, a typical load consists of a Kearfott Motor R119-2. The magnetic amplifier will produce phase-reversible a-c output for polarity-reversible d-c input signal.
American Research & Manufacturing Corp. **3375**

Insulation Tester—Model 8540 arc resistance tester that has been announced is a compact bench-type instrument suited for both laboratory and production quality control applications. This instrument provides 15 kv at 60 ma ac, for testing the ability of solid electrical insulating materials to resist the action of an arc, in accordance with ASTM Specification D 495 and Federal Specification LP406B.
Associated Research, Inc. **3376**

Temperature Measurements—Accurate temperature measurements of liquids at nearly any depth from a few feet to thousands of feet is now possible by means of long lead lengths developed for use with A+ Thermophil instruments.
Atkins Technical, Inc. **3377**

Laboratory Mixer—A new laboratory mixer, the "Micro-Mixer," especially designed to be effective for small, difficult-to-mix liquid-solid combinations has been announced. The Micro-Mixer is so named because of its ability to mix tiny batches of material in volumes from ½ to 2 oz.
Atlantic Research Corp. **3378**

Flux Analyzer—New instrument is designed to measure magnetic flux density with extreme accuracy. Though designed specifically to measure magnetic fields in traveling-wave tube solenoids, the instrument can be used for determining flux density in magnets, Klystron coils, and other products that have a linear field. Based on a phenomenon known as nuclear magnetic resonance, the analyzer can measure absolute flux density to an accuracy of 10^{5} with a differential capability of 10^{6}. The field density covered is 100 to 10,000 gauss.
Automation Industries, Inc. **3379**

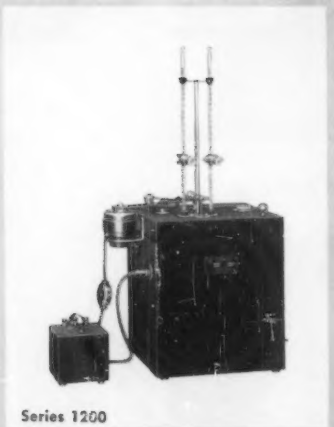
Flame Detector—Ultrasensitive hydrogen flame detector accessory, which has a typical sensitivity of 50 parts per billion full scale, is especially suited for detecting the presence of minute traces in complex organic compounds. Sensitivity depends to some extent on the component being detected. In analyzing a typical C_8 component, the detector has a sensitivity of 1.5×10^{-13} moles per sec full scale. Operating under identical chromatographic conditions, the hydrogen flame detector will produce signals over 10,000 times greater than those of a conventional thermal conductivity cell.
Beckman Scientific and Process Instruments Div. **3380**

Transistorized Cleaner—The Model LGT-40 transistorized ultrasonic cleaner

(*Continued on next page*)

PARR Calorimeters . . . For determining the heat of combustion of solid and liquid fuels

Series 1300


Series 1200

Series 1400

PLAIN TYPE with non-metallic, dead-air insulating jacket. Can be equipped with either single or double valve, Parr self-sealing oxygen bombs. Excellent for routine tests of coal, petroleum products and foodstuffs, also for student instruction in calorimetry.

ADIABATIC TYPE with brass water jacket enclosed in plastic veneered wood case. Can be equipped with any of several Parr self-sealing oxygen bombs. Suitable for either adiabatic or isothermal operation. Widely used for both routine and research calorimetry.

PEROXIDE BOMB type uses sodium peroxide powder instead of oxygen. Non-metallic, dead-air insulating jacket is similar to Series 1300. Recommended for routine tests of coal, coke and certain petroleum products, especially where compressed oxygen is not readily available.

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Branson Ultrasonic Corp. 3381

Strain-Gage Recording System—A new, extremely versatile, wide-range digital recording system for all combinations of strain gages and strain-gage transducers, the Model ASB-100VS, is designed to scan automatically 100 channels of information and is easily expanded to 200 channels by adding modular scanning units.

Bytrex Corp. 3382

Ultrasonic Tester—Model CM100 ultrasonic materials tester is a precision engineered instrument used for nondestructive inspection of material that can support ultrasonic waves, that is, metals, plastics, ceramics, etc. Uses include: flaw detection, either surface or internal, thickness measurement from one side, and determination of physical and structural properties.

Circo Ultrasonic Corp. 3383

Nitrogen Analyzer—Just released is the new automatic nitrogen analyzer. A fully automated means of performing the time-tested micro-Dumas method, within its 12- to 15-min cycle, it can perform a complete determination of nitrogen content. It will measure nitrogen in an almost unlimited variety of materials—pharmaceuticals, foods, fabrics, fertilizers, chemicals—and it is excellent for numerous determinations presently made by the Kjeldahl process.

Coleman Instruments, Inc. 3384

Test Chamber—Model FBV 8-3-3 features vibration access ports through the bottom and through the side. A hydraulic lift assembly permits raising or lowering the chamber heights to accommodate vertical or horizontal vibration. This lift also permits adjustment to fit various shaker heights. The chamber is mounted on heavy-duty 5-in. diam casters with wheel locks. Standard temperature range −100 to +300 F, or when ordered, +100 to +500 F.

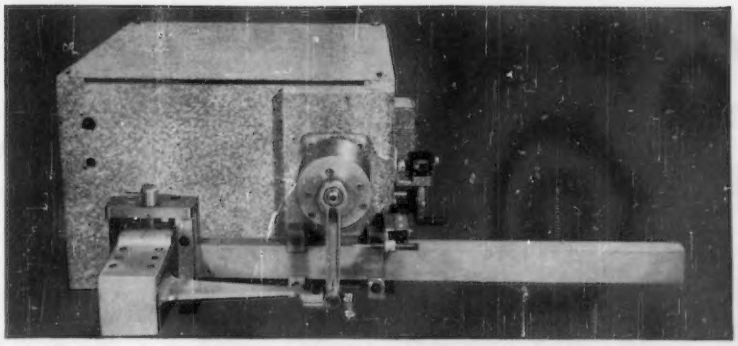
Conrad, Inc. 3385

Product Recorder—A compact product recorder suited for watt or kilowatt recording and for multiple measurements such as weight times speed and flow times density has been announced. The new Model 6717 product recorder houses two independent measuring systems within a single case.

Daystrom, Inc. 3386

Automatic Ultrasonic Tester—The Mault is a compact, fully automatic, ultrasonic inspection tank (size 26 by 30 by 26 in.) which can be used as an experimental ultrasonic parts-testing device in university, industrial, and government research and development laboratories. It may serve as an ultrasonic standards device for establishing production test settings under dynamic inspection conditions and is suited for automatic production testing of small parts, using

(*Continued on p. 88*)



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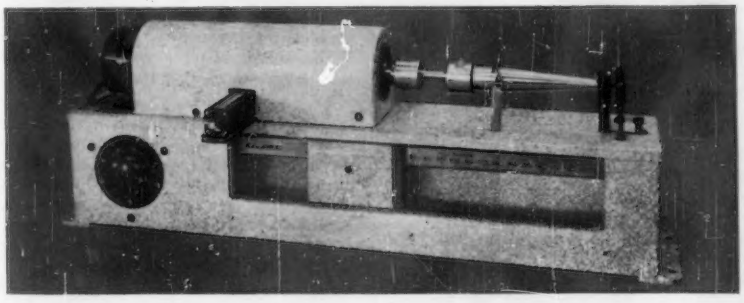

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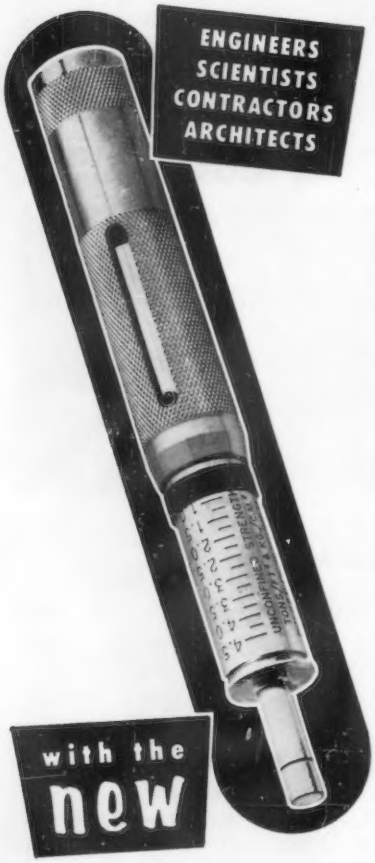

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LABORATORY ITEMS

(*Continued from p. 87*)

either the immersion or contact inspection techniques.
Elion Ultrasonics, Inc. 3387

Thermocouple—A new expendable immersion thermocouple for measuring molten metal temperatures has been developed. Primarily designed for measuring steel temperatures in both open hearth and electric furnaces, it may be used with equal efficiency with other molten metals.
Engelhard Industries, Inc. 3388

Chloroform—Ultrapure chloroform is the newest addition to the Fisher line of "Spectranalyzed Grade" solvents developed specifically to expedite spectrophotometry, chromatography, special synthesis, and sensitive extractions.
Fisher Scientific Co. 3389

Data Logger—The new 100-channel data logger, Model 179, for strain gage, thermocouple, and millivolt inputs has been announced. It is a medium-speed instrumentation system which will print out in decimal notation 100 channels of strain gage or temperature data in an elapsed time of 20 sec.
Gilmore Industries, Inc. 3390

Screens—The new Gilson Porta-Screen, a portable screening unit for size testing blacktop and concrete aggregates, ores, and similar materials is now available. The new screen may be hand or motor driven, and handles samples up to 25 lb in a practical size range of 1½-in. to 200-mesh.
Gilson Screen Co. 3391

Vacuum Gage—Battery-operated, transistorized vacuum gages with ranges of 0 to 1000 μ or 0 to 20 mm of mercury are now available. Portable or panel-mounted models are available in either range.
Hastings-Raydist, Inc. 3392

Furnace—The furnaces built for 2200 F operation feature vestibules on each end of the heating chamber to reduce heat losses and effectively extends the length of the uniform hot zone. Heat source is a helical coil, high-temperature alloy heating element mounted in semicylindrical refractories of the "Multiple Unit" design. These heating units can be arranged for multiple-zone temperature control to provide optimum temperature uniformity over an extended length.
Hevi-Duty Electric Co. 3393

Furnaces—Infinite zone control switches on Dyna-Trol industrial electric furnaces control the rate of temperature input; these control switches allow for complete and accurate equalization of vertical zone temperatures at any time-temperature curve.
L and L Mfg. Co. 3394

Stirrer—Stirrer called the "Pyro-Magnestir" was designed to fill the needs for laboratory stirring of larger vessels where controlled heat is a factor. The unit is claimed to be especially effective for both open or closed vessels using glass or Teflon-covered bars.
Labine, Inc. 3395

Flat-Rod Micrometer—A new flat-rod micrometer depth gage for easier, more accurate measuring has been announced. The new No. 613 Series flat-rod depth gage allows measurements to be made at side of hole, avoiding extra depth made by drill point. Rod can be turned 360 deg to any position. Once set, rod won't turn while measuring, won't walk away from setting. Graduations on thimble have each thousandth numbered.
The Lufkin Rule Co. 3396

Magnaflux Materials—A new development is the convenience of magnetic particle inspection materials available in pressurized spray cans and plastic squeeze-bottles. These materials can be used with any of the magnetic particle inspection equipment or test kits already in operation throughout industry.
Magnaflux Corp. 3397

Dead-Weight Gage—A new dead-weight gage, Type WG, designed to measure pressure, using a piston loaded with weights and operated by water, has been announced.
Mansfield & Green, Inc. 3398

Ultrasonic Cleaning—New ultrasonic cleaning and processing systems are now available. They may be used singly or unitized for specific manufacturing or maintenance procedures.
C. & E. Marshall Co. 3399

Carbon-14 Compounds—Three new radioactive carbon compounds, cortisone-4-C^{14}, cortisone -4-C^{14} acetate, and 1,2,3,4,-dibenzanthracene - 9 - C^{14}, have been added to the list of over 200 carbon-14 compounds available. These compounds are of particular value in the fields of chemistry, biology, and pharmacology.
Nuclear-Chicago Corp. 3400

Hardness Testing—A new metal hardness testing machine incorporating a direct-reading Brinell hardness gage has been announced. By combining accurate load application with simultaneous read-out of Brinell hardness level, the direct-reading Air-O-Brinell machine provides speed and accuracy for production-line Brinell hardness testing.
Tinius Olsen Testing Machine Co. 3401

Specific Gravity—An accurate, non-electric instrument for direct and continuous indication of specific gravity in flowing process liquids, the Princo Densitrol W-756, features a design concept that permits immediate availability in custom ranges from stock, has double-tough Pyrex body for impact resistance and is immune to almost all corrosive liquids due to its Pyrex tantalum and Teflon wetted surfaces. The density sensing device is a totally submerged, chain-weighted Pyrex plummet. Accuracy is said to be ± 1 per cent of total scale.
Precision Thermometer and Instrument Co. 3402

(*Continued on p. 89*)

LABORATORY ITEMS

(*Continued from p. 88*)

Channel Analyzer—New RCL 256 channel analyzer, Model 20613, features preselected automatic programming, magnetic tape auxiliary memory, 600 to 2500 v high-voltage power supply, single push-button manual operation, and six modes of readout. Desired analyzer cycle, including any or all of twelve separate operations obtainable.

Radiation Counter Laboratories, Inc. **3403**

Dielectric Tester—Type 1000-B is designed to give the required sensitivity and accuracy for the new ASTM Liquid Immersion Method D 1531. This Ultra-Hi-Q coil resonates with about 220 $\mu\mu f$ and is designed as a companion to the benzene cell described in this method.

Rutherford Research Products Co. **3404**

Dielectric Heaters—High-frequency dielectric heaters especially designed for laboratory development and general processing requiring rapid thorough heating are now being offered.

Sherman Industrial Electronics **3405**

Ionization Gage—A new series of ionization gage controls for the accurate and uniform measurement of ultra-high vacuum has been introduced. The series comprises four models: Models IG-50 and TIG-50 with a range from 10^{-2} to 10^{-9} mm of mercury, and Models IG-60 and TIG-60 with a range from 10^{-3} to 10^{-10} mm of mercury. The TIG units combine a thermocouple gage circuit with the ionization gage.

F. J. Stokes Corp. **3406**

Bubble Detector—Ultrasonic bubble detector can be used to detect undesirable or controlled bubbling in almost any liquid, in open or closed vessels, pipes, or flumes. Whether the liquid is static or flowing does not affect instrument efficiency. The bubble detector can be coupled with any type of indicating, recording, or controlling instrumentation.

Taylor Instrument Cos. **3407**

Hot Plate—A new round hot plate featuring a small size (3½-in. diam top) and precision control from 6 C above ambient to 370 C is announced. Type 2300 Thermolyne hot plate is especially recommended for those laboratory and shop applications where a small single or multiple precision heat source is needed.

Thermo Electric Mfg. Co. **3408**

Press—A new 30-ton hydraulic laboratory motorized press featuring convenient "easy-reach" working height has been introduced. All dials and controls are mounted on a sloping panel on the instrument console.

Wabash Metal Products Co. **3409**

Environmental Chamber—An environmental chamber for research and development of dentritic semiconductor materials and other applications requiring precise and accurate temperature control is offered. Called Model WF-12-125+400, it has an adjustable temperature range from −125 to −400 F. Removing 7270 Btu from the product load in 15 min, the mechanical refrigeration system is said to be the most advanced ever developed.

Webber Mfg. Co. **3410**

Dial Thermometers—Immersion-type vapor-actuated thermometers for piping installations feature ease of reading and dependable accuracy throughout the entire working range, a progressively graduated scale for use in the upper two-thirds of the range, and economical construction with all brass fittings.

Weksler Instruments Corp. **3411**

CATALOGS & LITERATURE

Gage Catalog—A 16-page catalog, *Pressure Measuring Elements*, covering diaphragm and Bourdon tube elements is now available. This catalog, *No. 900*, illustrates the characteristics of standard *USG* measuring elements.

American Machine and Metals, Inc. **6233**

Hardness Chart—A chart showing the approximate relation between hardness by various testing systems and tensile strength of carbon and alloy steels has been issued. The hardness systems covered are Brinell, Monotron, Vickers, Rockwell (B, C, and E scales), and Scleroscope.

The Babcock & Wilcox Co. **6234**

(*Continued on p. 90*)

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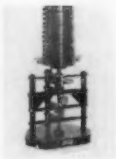

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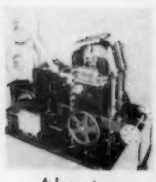

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FOR FURTHER INFORMATION CIRCLE 649 ON READER SERVICE CARD

CATALOGS & LITERATURE

(*Continued from p. 89*)

Radioisotope Wall Chart—Now available is a radioisotope wall chart containing important information on dosimetry of radioisotopes, decay tables, optimum counts chart, gamma-ray absorption curves, and typical gamma spectra.
Baird-Atomic, Inc. 6235

Infrared Accessory—Tracking accuracy control (TAC), a new accessory for Beckman IR-4 and IR-7 infrared spectrophotometers, is fully described in *Bulletin 775*.
Beckman Scientific and Process Instruments Div. 6236

Metal Digest—The external house organ, *Metal Digest, Vol. No. VI*, features an article on photomicrography print development.
Buehler, Ltd. 6237

Heating Jackets—Laboratory heating jackets and tapes are described in an 8-page folder, *Catalog No. 58*.
Burrell Corp. 6238

Laboratory Analysis—Instruments for laboratory analysis, process control, and research are described in a new 16-page general catalog, *Bulletin No. 1313*. Described are techniques and instruments for leak detection, mass spectrometry, chromatography, moisture monitoring, and other types of analysis and control.
Consolidated Electrodynamics Corp. 6239

Recorders—Control and recording instruments are illustrated and described in an 8-page, 2-color bulletin.
Datex Corp. 6240

Glass Vacuum Systems—This catalog is devoted exclusively to standard and custom-built glass vacuum systems. It contains a complete description of parts and many accessory items. There is also detailed information on installation and applications of these systems.
Delmar Scientific Laboratories 6241

Apparatus Catalog—A 2-color, 72-page catalog lists scientific instruments and apparatus.
Eberbach Corp. 6242

Laboratory Catalog—A fully-illustrated 48-page catalog, *Fisher Laboratory Specialties*, is now available. It describes instruments, appliances, and other laboratory equipment.
Fisher Scientific Co. 6243

Laboratory Catalog—*Labitems, Vol. 9, No. 1*, features open-end McLeod Gage. There are 16 pages of additional items.
The Emil Greiner Co. 6244

Laboratory Catalog—A 2-color, 16-page *Catalog No. 19* details balances, vacuum pumps, and other laboratory equipment.
Harshaw Scientific Co. 6245

Nondestructive Testing—A new instrument for the nondestructive measuring of crack depths in forgings, castings, steel bars, rods, etc., is described in a new folder. Using an alternating medium-frequency current of low intensity and voltage, the gage measures the drop in potential against a given section of the surface. With a sound (solid surface) conductor the loss is equal on any portion. In the presence of a crack the drop in potential is greater, and by measuring this the depth of the crack can be immediately read off the instrument. It is adjustable to two measuring ranges, from 0 to $^3/_{16}$ and 0 to 1 in.
Iroquois Tool Supply Co. 6246

Potentiometer—A 2-page data sheet describes the new 8692 single-range and the 8693 double-range portable temperature potentiometers and their advantages for making accurate temperature or millivolt measurements in industrial plants or in research laboratories.
Leeds & Northrup Co. 6247

pH Data Sheet—Complete information on the full line of industrial-type pH and Redox electrodes and electrode mountings is contained in new 4-page *Data Sheet NS5(1)*. Two tables aid in selecting the type of electrode and mounting needed for a wide variety of applications.
Leeds & Northrup Co. 6248

Thermocouple Components—A newly designed line of QuiK-Konnect thermocouple components for quick and easy connecting of thermocouples to extension wire has been made available. A list of the various components and a description of each is contained in *Specification Sheet FS 005-3*.
Minneapolis-Honeywell Regulator Co. 6249

(*Continued on next page*)

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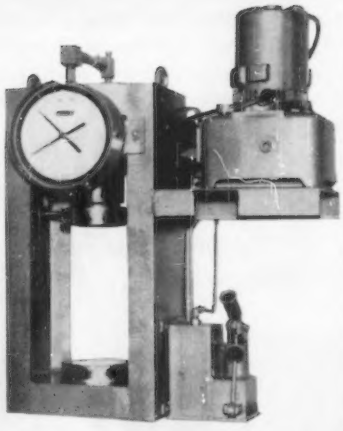

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CATALOGS & LITERATURE

Oxygen Bomb Calorimetry—Detailed instructions for measuring heats of combustion of solid and liquid combustible materials are given in a new 56-page *Manual No. 130* on "Oxygen Bomb Calorimetry and Combustion Methods." Safety and maintenance instructions for oxygen combustion bombs, a section on oxygen bomb methods for chemical analysis, and a selected bibliography of oxygen bomb and calorimetric methods are included in this comprehensive book.

Parr Instrument Co. 6250

Pipet Catalog—A completely new illustrated catalog of Lambda-Pettes micropipets is available. It lists micropipets and their controls and related microtransfer devices such as syringe pipets, miniature delivery syringes, and gastight syringes.

Research Specialties Co. 6251

Efflorescence Chalking—The causes of efflorescence and early chalking on painted masonry surfaces, and effective methods for overcoming and preventing such deterioration are discussed in a 48-page publication.

Rohm & Haas Co. 6252

Laboratory Ovens—*Bulletin O*, featuring the new Sargent analytical laboratory oven and the electric drying laboratory oven, has been released. The analytical oven is designed to emphasize conduction and radiation as modes of heat transfer and to minimize the contribution of convection, thus achieving uniform temperature throughout the entire aluminum interior chamber.

E. H. Sargent & Co. 6253

Chromatography Book—Complete catalog of chromatographic apparatus and supplies is now available. Book also features a complete spectrophotometry section. All types of intruments and supplies for gas, paper, and column chromatography are included. Featured in this 28-page book are gas chromatographs with all components, attachments, and accessories including fraction collectors, recorders, integrators, coils, and syringes.

Schaar and Co. 6254

Durocalibrator—*Bulletin R-16* describes the Durocalibrator designed for field use in testing and calibrating Shore Durometer rubber hardness testers.

The Shore Instrument and Mfg. Co., Inc. 6255

Specimen Cutter—A data sheet which both illustrates and describes the new TMI precision test specimen cutter is available.

Testing Machines, Inc. 6256

Soil Testing—A 16-page catalog, *Digest No. 2*, devoted to new and improved testing apparatus relating to soils, bituminous, concrete, and general testing has been announced.

TESTlab Corp. 6257

Hardness Tester—This new *Bulletin CRS-60* describes the Kentrall line of four new motorized hardness testers. By removing major test loads automatically, these new motorized hardness testers increase reproducibility of test results and raise the productive capacity of the machine.

The Torsion Balance Co. 6258

INSTRUMENT COMPANY NEWS

The Budd Co., Philadelphia, Pa.—has acquired the assets of Metrol, Inc., manufacturers of electromagnetic nondestructive testing equipment with headquarters in Pasadena, Calif. The announcement was made by Dr. John H. Buck, vice-president and general manager of the Instruments Division of the Budd Co. Purpose of the acquisition is to expand the Division's nondestructive testing equipment line. Metrol will continue to operate in California for the present as a new department of the Budd Company's Instruments Div.

Laboratory Glass and Instruments Corp., New York, N. Y.—Mr. Joseph Buchler, president of Laboratory Glass and Instruments Corp., announces the change of the firm's name to Buchler Instruments, Inc. Location of plant and office remain at 514 West 147th St., New York 31, N. Y.

(*Continued on p. 92*)

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FOR FURTHER INFORMATION CIRCLE 652 ON READER SERVICE CARD

LABORATORY NEWS

Almay Research and Testing Corp., Los Angeles, Calif.—has expanded its special fastener-testing facilities with the installation of cryogenic and elevated-temperature test chambers, announced by Harry S. Brenner, president. The new extreme-temperature equipment permits testing of bolts, screws, nuts, rivets, and similar structural fasteners through a temperature range as low as −320 F and as high as 2000 F. The advanced environmental testing is being carried out to establish strength requirements for high-performance fasteners used in new-type airframes, missiles, and power plants. In the past, major emphasis of related fastener testing programs has been on obtaining mechanical properties such as room-temperature tensile, shear, fatigue, and moderate elevated-temperature creep and stress-rupture strengths.

MATERIALS NEWS

Adhesive—Development of FABTEX, a new noninflammable latex adhesive for laminating polyurethane to fabric is announced. FABTEX is waterproof and resistant to solvents. The adhesive is self-vulcanizing.

Adhesive Products Corp., New York, N. Y.

Low-Fuming Bronze Brazing Alloy—Available in both bare and flux-coated form, a new low-fuming bronze brazing alloy is designed for general-purpose, all-around welding and brazing work. Its low melting point allows free flow and produces a tough, yet ductile weld deposit of very high tensile strength. It meets all AWS, ASTM, and Federal specifications. This rod is for both fusion welding and surface buildup. An oxy-acetylene welding and brazing rod, it is degasified and deoxidized for low-fuming characteristics.

American Brazing Alloys Corp., Pelham, N. Y.

Crystal Gazing—A new picture of crystal growth, based on similarities in natural phenomena, is advanced for the first time in the latest issue of *Research Comments* entitled "Crystal Gazing."

Evans Research, New York, N. Y.

High-Alloy Heat- and Corrosion-Resistant Castings—A new, fully illustrated, 64-page booklet, *Heat-Resistant Castings; Corrosion-Resistant Castings; Their Engineering Properties and Applications*, is designed as an aid to those interested in stainless-steel and high-alloy casting selection, design, and production. It offers a comprehensive picture of all types of stainless-steel and high-alloy heat- and corrosion-resistant castings and their applications.

The International Nickel Co., Inc., New York, N. Y.

Expanded Teflon Tubing—Thin and standard-wall Teflon-TFE tubing which has been expanded mechanically and which will recover the original dimensions promptly, clamp tightly to the inserted object to form a tighter fit when heat is applied and retain the outstanding electrical, mechanical, and chemical properties of Teflon is now available. The tubing can be obtained in 11 basic colors, printed and cut to required lengths. The tubing can be made cementable and offers the advantages of: good dielectric strength (500 to 1000 v per mil); lowest dielectric constant (2.0) and dissipation factor (0.0002) of any solid dielectric; no change of electric properties with temperature (−25 to +250 C) or frequency (60 cycles to 100 Mc); and zero moisture absorption.

Pennsylvania Fluorocarbon Co., Inc., Philadelphia, Pa.

Rubber-Base Adhesive—A new rubber-base adhesive for cementing highly plasticized vinyls to many other materials that resists oil, gasoline, water, heat and cold, and migration of oils and plasticizers from adjacent materials has been announced. The new adhesive is particularly well suited for bonding vinyls to metals, woods, cloth, and leather.

Schwartz Chemical Co., Inc., Long Island City, N. Y.

(Continued on next page)

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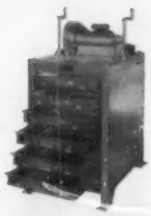

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High-Temperature Alloy—A new 12-page booklet, *W-545 Vacuum-Melted High-Temperature Alloy*, is complete with photomicrographs showing structures of the material and many tables and graphs illustrating the material's properties. In addition to general information on applications, other sections of Technical Data Booklet 52-263 deal with metallurgical characteristics, physical properties, mechanical properties, creep and creep-rupture properties, availability, and material processing of W-545 alloy. The alloy is an austenitic iron-base alloy containing nickel, chromium, and relatively small portions of molybdenum, titanium, boron, silicon, and manganese.

Westinghouse Electric Corp., Pittsburgh Pa.

The cost of building a commercial nuclear power plant in the U. S. today is estimated at $300 to $400 per kilowatt vs. $100 to $200 per kilowatt for a conventional power plant. According to engineers at Arthur D. Little, Inc., it is not likely that the per-kilowatt cost of nuclear power plants will fall below $200 to $250 in the "forseeable future."

Papers to Appear in Future Issues of the ASTM Bulletin

Measuring the Lamination Factor of a Small Steel Disc—Charles Begovich, Delco Products Division of General Motors Corp.

The Rupture of Plastics by Dynamic and Static Flexure—B. Bossu and P. Dubois, Centre d'Etudes des Matieres Plastiques.

Development of Test Method for Air-Entrainment of Standard Ottawa Sand—M. R. DeFore and H. J. Corah, National Bureau of Standards.

A Gravimetric Method for the Determination of Barium Oxide in Portland Cement—C. L. Ford, Portland Cement Assn.

Influence of Particle-Size Distribution of Sand on Strength and Workability of Vibrated Mortar—F. Giuliani and Raul Suarez, University of Cuyo, Argentina.

The Creep Characteristics of Compression-Molded Polyethylene—G. R. Gohn and J. D. Cummings, Bell Telephone Laboratories, Inc.

On the Measurement of Relative Density of Sand—S. Kitago and F. Kozaki, Hokkaido University, Japan.

Comparison of Four Particle-Size Distribution Techniques—A. I. Michaels, T. L. Weaver, and R. C. Nelson, Sylvania Electric Products, Inc.

Devices for Simulating Gun Firing Under Static Conditions—J. P. Noonan, R. W. Heinemann, S. J. Lowell, and P. B. Tweed, Picatinny Arsenal.

The Tensile Properties of Some Engineering Materials at Moderate Rates of Strain—R. F. Steidel, Jr., and C. E. Makerov, University of California.

Measurements of Human Reaction to Hardness of Floor Covering—Rolf Schjodt, Norwegian Building Research Inst.

Standardization's Role in the Purchasing Function—W. C. Brunberg, Western Pacific Railroad Co.

Comments on ASTM Standards for Highway Materials—F. N. Hveem, California Department of Public Works.

Sound Standards Stimulate Manufacturing—Paul McCoy, American Bitumuls & Asphalt Co.

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FOR FURTHER INFORMATION CIRCLE 655 ON READER SERVICE CARD

(*Continued from p. 78*)

Chemical Analysis of Resin-Based Coating Materials

Edited by C. P. A. Kappelmeier; Interscience Publishers, Inc., New York (1959); 630 pp.; Illus.; $19.50.

Reviewed by Gordon M. Kline, National Bureau of Standards, Washington, D. C.

THE LATE Dr. Kappelmeier enlisted the cooperation of analytical chemists in six countries to prepare this authoritative compilation of information on testing organic coating materials. The methods and data are taken both from the literature and from unpublished work of the authors. In covering the oil-base paints there are noteworthy chapters on the analysis of rosin and rosin derivatives and of the fatty acid, dibasic acid, and polyvalent alcohol components in alkyd resins. Chapters on lacquers and latex paints present methods for the indentification and quantitative determination of cellulosic, rubber, and resinous-film-forming compounds. The coverage of paint components is completed by excellent chapters dealing with solvents and thinners and with organic and inorganic pigments. An outstanding chapter reviews the use of titration methods involving chelate complexes in the analysis of the metal cations of pigments and driers.

The organization of the chapters in this book seems questionable. For example, the chapter on latex paint appears in Part 1, Oil-Based Coating Materials, whereas fatty-acid analysis is covered in Part 3, Selected Chapters. Sulfonamide resin analysis is dealt with in Part 2, Lacquers, whereas chapters on polyester and isocyanate resins are in Part 3.

This book, complementing the recently published *Analytical Chemistry of Polymers* from the same publishing house, provides the analyst of coating materials with a comprehensive reference work in this field. The editing and printing are of characteristic high quality. It is a fitting monument to a chemist who played a prominent role in the development of the science and technology of modern protective coatings.

Cemented Carbides

Paul Schwarzkopf and Richard Kieffer; The Macmillan Co. (1960); 349 pp.; Illus., $15.

Adapted from publisher's description

MESSRS. SCHWARZKOPF, Kieffer, and their staff have drawn upon sources in the United States and in Western and Eastern Europe to prepare this definitive work on cemented carbides.

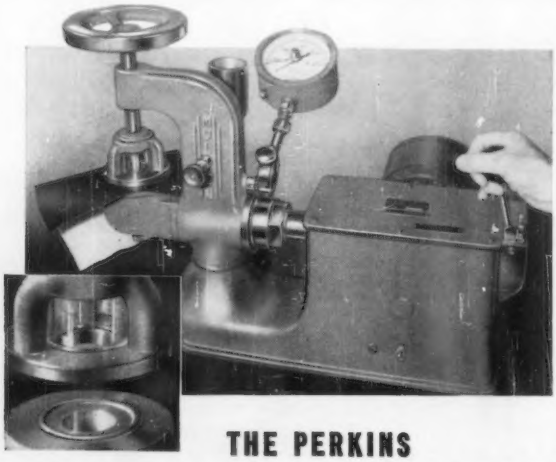
The opening chapters furnish background information and describe the methods of producing carbides and other metallic refractories. The middle chapters describe the mechanical and chemical properties of all the cemented carbides in commercial production and those which are being produced in experimental quantities (of special interest is a chapter on the new oxide and boride cutting materials). The final chapters concentrate on the many applications of the cemented carbides to the machine tool, mining, defense, and other industries.

Vacuum Processing in Metalworking

J. Wesley Cable; Reinhold Publishing Corp. (1960); 202 pp., Illus.; $5.50.

Adapted from publisher's description

THE RELATIVELY new field of vacuum technology receives complete, practical treatment here. The book encompasses the complete range of operations in the metalworking field. The first few chapters cover the general phases of vacuum technology, such as the means of producing low pressures and their measurement. Following these, the author devotes a chapter to a particular phase of vacuum processing. He also includes the latest developments, among them electron beam heating. In general, the aim of the book is to present vacuum technology in a descriptive manner, rather than in a highly technical form. As a result, it is beneficial to any industry involved in the refining and processing of metals.



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INDEX TO ADVERTISERS

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ALL AMERICAN TOOL & MFG. CO. 76

BUEHLER LTD. 65
BURRELL CORPORATION 75
BRANSON INSTRUMENTS, INC. 85
THE BUDD COMPANY
INSTRUMENTS DIV. 2, 80, 87

CAMBRIDGE INSTRUMENT CO., INC. 92
COSA CORP. 69
COULTER INDUSTRIAL SALES CO. 83
CUSTOM SCIENTIFIC INSTRUMENTS, INC. 89

DELTA CHEMICAL WORKS 94
DILLON & CO., W. C. 82

EASTMAN KODAK CO. 63
EBERBACH CORP. 95

FISCHER SCIENTIFIC CO. 77
FORNEY'S INC. 90

GENERAL DYNAMICS CORP.
CONVAIR DIV. 3
GENERAL RADIO COMPANY ..... IBC
THE GILSON SCREEN CO. 92
GRAPHIC SYSTEMS 70
CRIES INDUSTRIES, INC. 78
GRIEVE-HENDRY CO., INC. 78

H-B INSTRUMENT COMPANY 76
HIGH VOLTAGE ENGINEERING CORP. 67
HOGGSON & PETTIS MFG. CO. 81
HOUSTON INSTRUMENT CORP. 70

INSTRON ENGINEERING CORP. ..... IFC
INSTRUMENTS FOR RESEARCH & INDUSTRY 72

KLETT MFG. CO. 90

OLSEN TESTING MACHINES CO., TINIUS ..... OBC
OZONE RESEARCH & EQUIPMENT CORP. 68

PARR INSTRUMENT CO. 86
PERKINS & SON, INC., B. F. 94
PICKER X-RAY CORP. 4

RESEARCH APPLIANCE CO. 73

SARGENT & CO., E. H. 71
SAUTER OF N. Y., INC., AUGUST 66
SCOTT TESTERS, INC. 79
SHORE INSTRUMENT & MFG. CO., INC. 95
SIEBURG INDUSTRIES, INC. 82
SOILTEST, INC. 88
SYNTRON COMPANY 93

TESTING MACHINES, INC. 91
THERMO ELECTRIC MFG. CO. 84
THOMAS CO., ARTHUR H. 81
THWING-ALBERT INSTRUMENT CO. 74

UNITED STATES TESTING CO. 85
UNITRON INSTRUMENT DIVISION 96

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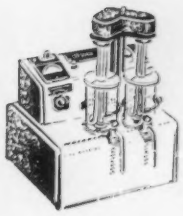

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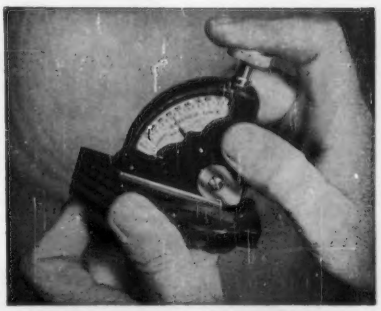

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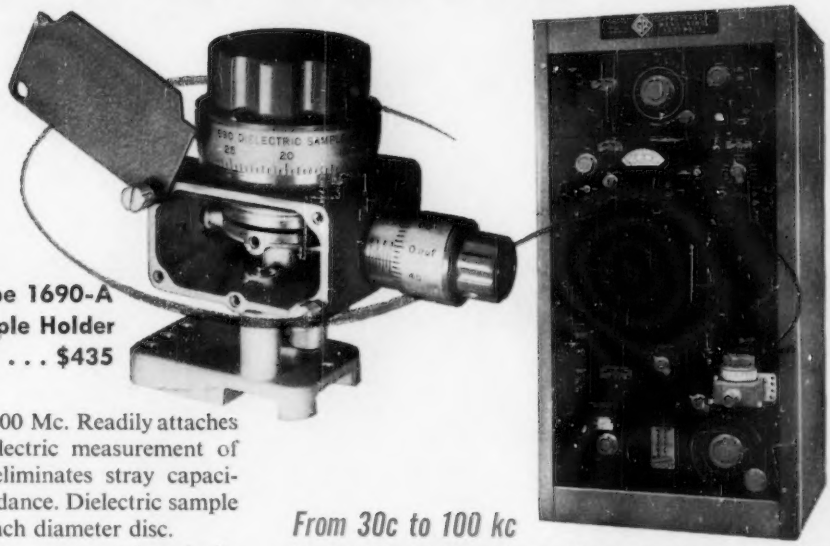

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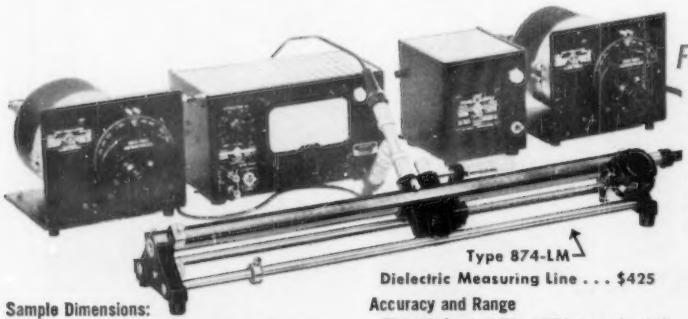

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For Measurements From 200 to 5000 Mc

The Type 874-LM Dielectric Measuring Line . . .

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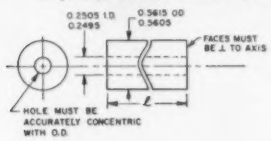
A cylindrical dielectric specimen is fitted into the open end of the line. The frequency of the signal source driving the line is adjusted until a voltage minimum is detected with the probe about a centimeter away from the sample. Dielectric constant and dissipation factor are then quickly calculated from two simple algebraic expressions.

Sample Dimensions:

Length dependent upon K and frequency



Accuracy and Range

Dielectric Constant (K): $\pm 2\%$ between 1 and 10
Dissipation Factor (D): $\pm(5\% + 0.0001)$ between 0 and 0.05

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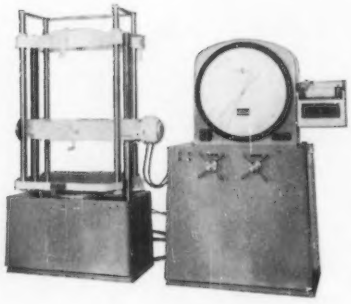

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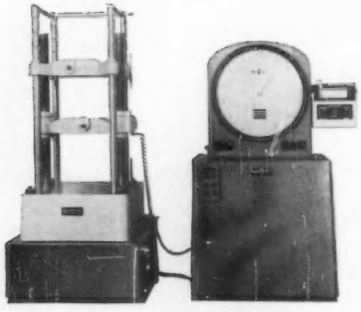

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